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SILICON CHIP
www.siliconchip.com.au

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SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

Subscription rates: $94.50 per year in Australia. For overseas rates, see the order form in this issue.

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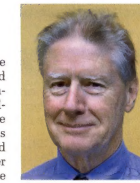
ISSN 1030-2662
Recommended and maximum price only.

Publisher's Letter

LEDs will be the universal light source



Back in the April 2007 issue we had a feature article on the proposed ban on incandescent lights. Introduced by Malcolm Turnbull, then Minister for the Environment and Water Resources, the ban was hasty and ill-conceived. Even then it was only predicted to produce a negligible reduction in Australian greenhouse gas emissions of 800,000 tonnes between 2008-2012 and a somewhat larger reduction of 4 million tonnes per annum by 2015. People were supposed to substitute compact fluorescent lamps (CFLs) and it was claimed that household lighting costs would then be reduced by up to 66 percent.

Overall, it was a very bad decision. Few householders could point to any reduction in their electricity consumption due to the installation of CFLs – they have no precise way of measuring it. Instead, they have had to pay substantially more for CFLs whose life has never come up to the claims made for them. Even this month we have a couple of letters of further bad feedback for CFLs. And now, to emphasise how stupid the ban has been, it's possible to buy mains voltage halogen "incandescents" which are apparently permitted under the on-going ban on incandescent lamps. How ridiculous. While no doubt halogen lamps will be more reliable than CFLs, they are not much more efficient than incandescents. They are considerably more expensive than equivalent incandescent lamps, as well.

To add insult to injury, electricity tariffs have since gone up by more than 60 percent (in Sydney, at least) which would completely obliterate any putative savings in household lighting costs.

The incandescent lamp ban was introduced by the then Liberal government and maintained by the following Labor government – proof that both sides of politics are equally capable of stupid decisions when it comes to any aspect of technology.

At the time of the ban, we commented that LED replacements were not viable for incandescents, being "expensive and not as bright as halogens". That situation is rapidly changing though, as this month's article on LED replacements for fluorescent lamps demonstrates. While still expensive in absolute terms, LED replacements for fluorescent tubes are now a viable choice in all new buildings, offices and factories and certainly should be considered for existing installations.

At the same time, LEDs are making inroads into virtually every lighting application. They are now standard in traffic lights and it is only a matter of time before they become universal for street lighting as municipal authorities are already evaluating LED replacements. These authorities will no doubt be driven by the substantial energy savings and likely much longer life of LEDs. LED street lighting should also have the advantage of less light pollution, with far less light scatter into oncoming drivers' eyes and into the sky.

LED replacements for incandescent lamps are already being produced and again, it is only a matter of time, perhaps a couple of years, before they become the standard light source where previously incandescents were universal. CFLs will be quickly displaced, recognised as a product which never lived up to its claims.

12V halogen lamps are also likely to be displaced by LED equivalents but they still have some way to go, as they are still not quite as bright, are expensive and heat dissipation is still a significant issue. Having said that, 12V LED replacements for halogens are already making inroads where power consumption is an important issue, particularly in boats, recreational vehicles and homes which are not connected to the grid.

Unfortunately, due to perennial lack of government planning to provide for electricity generation, electricity tariffs will continue to rise rapidly and that is without any consideration of the introduction of carbon pricing or an emissions trading scheme. LED replacements cannot come soon enough.

Leo Simpson

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Candles a considerable risk to TV sets

Last week was another where I saw a TV with a fresh 50mm disc impression from a candle embedded in the top of its cabinet. The lady who put it there was surprised that the solid looking silver cabinet was actually moulded from highly-flammable High Impact Polystyrene (HIPS) resin. In 1996, State Fair Trading departments, alarmed at a dramatic rise of house fires from modern TVs with flammable cabinets, drew up new regulations in consultation with manufacturers/importers for cabinet flammability.

The manufacturers would not agree to mandating flame retardant in the front of CRT TV sets, as they feared any price increase would affect sales. Despite these objections, regulations were drawn up to be introduced to coincide with the 1988 C-Tick EMI regulations. These regulations required that the material of the cabinet back of CRT TVs be tested as self-extinguishing for each model on sale.

Concerns were put to the new Liberal federal government that manufacturers needed time to clear stock, so the Howard Government placed a moratorium, until 1 July 2000, on the new regulation, allowing multinational companies to import or dump these sub-standard sets into Australia.

Regardless, these regulations do not stop TVs from catching fire if candles are placed on them or on the rare occasion of a power switch "fusing" or shorting out. I know of no regulations in relation to fire safety of flat panel TVs that also mostly use polystyrene cabinets. It is best not to leave equipment unattended if switched on at the wall and never place candles on top of them.

Tony Backhouse,
Narraweena, NSW.

Comment: candles might be romantic but they are always a fire risk.

Solar thermal power stations have major challenges

Although I'm a keen solar enthusiast, the thermal slant in your informative August 2010 "Solar Power – 24/7" article left me with mixed feelings. Solar thermal may well seem tempting but the article failed to mention that it's presently facing major challenges (both technical and economic), especially from photovoltaic (PV) systems.

This has largely arisen as a result of the Spanish government's 2009 slashing of very generous (but biasing) "green energy" subsidies. The resulting sharp reduction in commercial demand meant a global fall in PV prices, making simpler PV-based schemes relatively more attractive, especially when their increasing efficiencies are also considered.

PVs convert sunlight directly to electricity and essentially cease working after dark – charged battery banks being normally then needed. However, PV-based energy schemes can be immediately and progressively commissioned, with extensions as circumstances allow. Servicing and upgrading usually can be done without shutting down the entire operation. As PV arrays do not even need to be precisely arranged, irregular terrain or even disconnected sites can be utilised as well.

The fact that previously sun-baked land under the panels will become partially shaded may mean cropping or animal grazing can occur. Most PV technologies work better in cooler conditions and many still perform acceptably when off-angle or under cloudy skies, meaning simpler fixed panel mounting may be used, perhaps on otherwise idle rooftops. As the day-

Let the buyer beware – salespeople's advice is suspect

Your Publisher's Letter on TV sound (July 2010) brought up issues I totally agree with. Fortunately, the TV I purchased does have analog audio out, so I looked for an amplifier for top-quality sound. However, with a budget of just $250 and not much space, it was a tall order. In a leading store, the salesman directed me to a 5.1 system with speakers everywhere and really awful sound.

Legendary brands from the past like Sony and Yamaha were no help either, with one of them quoting full output at 10% distortion! Heck my 1970s amplifier in the lounge has about 0.5% distortion at high volume. So I looked at the bookshelf units and settled on a Panasonic with subwoofer for around $250. It's brilliant, apart from the bass sounding just a tad "plastic", due to the heavy plastic speaker boxes.

On CD, with the equaliser set right and a 1950s tune playing, it sounds a lot like the old Astor Concertmaster we had in the family during that era.

It's important when selecting TVs and amplifiers that we have a checklist of items we need, then use our eyes and ears. Also be sceptical of salespeople's advice. I went to three stores looking at Panasonic plasma TVs and staff at all three directed me to a recently superseded model, saying it was $200 cheaper but only lacked a couple of sockets.

By the third store, I was absolutely convinced their advice was flawed – the brilliance and contrast was less on the older model – and that indicates it has less reserve for long-term ageing. I paid the extra for the new model. Impulse buyers beware!

Kevin Poulter,
Dingley, Vic.

time energy harvesting is electrical, energy can be promptly and efficiently wired for immediate work (or centralised storage) – perhaps electric-vehicle charging or water pumping at regions quite some distance away.

In contrast to scalable PVs, solar thermal schemes must be designed to capacity at the outset, as they are really only economic at very large scale. Financial, engineering and servicing issues may then become extremely daunting. Tracking and focusing the changing daily and seasonal solar passage calls for complicated mechanicals and one shudders to consider how long it takes a tower to cool for safe access!

Extended cloud cover may also mean molten salts need external heating to prevent solidification. Because the sunniest regions are likely to be the driest, even the local availability of scarce water (to produce steam) may become an issue for solar thermal schemes.

Perhaps most tellingly, many energy schemes (both traditional and green) require lengthy construction periods before producing any output. Political and financial uncertainties arising during this phase may derail the project– Mildura's thermal tower scheme (featured in SILICON CHIP, July 2002) perhaps being typical.

At 62MWp, Portugal's Moura (Amareleja township) Photovoltaic Power Station is on track to become the world's largest PV installation. Some 380,000 "off the shelf" solar panels, many of which are on fixed structures, are arranged over 250 hectares. It's sited in one of the sunniest regions in Europe and construction (budgeted at some US$500 million) should further benefit an economically depressed region – see **http://www.youtube.com/watch?v=Gg-CgsQnUAU**

Stan Swan,
Wellington, NZ.

Compression ain't compression

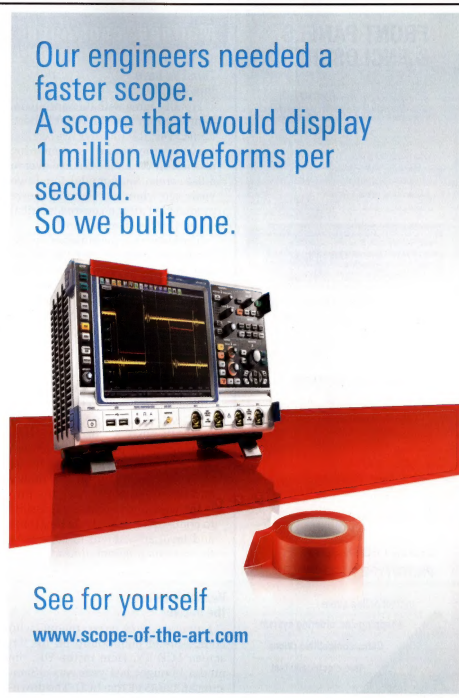
Next time compression in radio is discussed, can we distinguish between the two forms of it? Poul Kirk (Mailbag, July 2010) certainly confuses things by describing "all audio compression" as the discarding of presumed unwanted detail in the digital transmission. Unless by "detail" he includes musical dynamics, the compression I know and hate – and used on all analog radio including, sometimes ruinously, ABC Classic FM – irons out the climaxes and boosts the quiet passages.

I am also amused by the references to "old fashioned analog FM". Your younger readers may be surprised to know that the much older-fashioned AM stations of the ABC decades ago transmitted the full dynamic range – there was only a limiter at the top to prevent transmitter overload – with a frequency range to 15kHz! So in terms of vital musical dynamics, has radio gone forwards or backwards?

Brian Wallace,
Dora Creek, NSW.

Comment: in many ways we have gone backwards, especially in respect of the audio quality from radio broadcasts, flat-panel TV sets and MP3 players (which many think have reasonable sound quality).

High fidelity is a lost cause as far as most people are concerned and they simply don't realise how good recorded music can sound.



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Mailbag: continued

Thin TVs have thin sound

I totally agree with the sentiments expressed in the July Publisher's Letter. Yes, the pictures are terrific, however the sound is something else again. We had to change over to a flat-screen Sony model some two years ago when our German Loewe model died after a severe electrical storm (EHT system failure).

The Loewe had decent-sized speakers facing forward and the sound quality was on a par with the picture quality. Also the sound could be connected to the stereo system for even better audio performance. As we live in an area with poor analog TV reception, the Loewe was fed from a set-top box and performed extremely well.

The change to a flat-screen model giving a similar sized picture went well, with the picture quality on a par with what we had previously been used to. But the sound was something we were unable to get used to. Depending on the timbre and sex of the person/s in the program, we found it almost impossible to come up with a satisfactory tonal and level adjustment to cope with the various program mixes.

Sony does provide the facility of permitting connection to a stereo system as well as providing a headphone output. Connecting to the stereo system did not produce a dramatic improvement in the sound quality, so in the end we opted to buy a pair of wireless headsets, (OK we have ageing ears, so that could be part of our problem).

The headsets have added considerably to our enjoyment of TV and enabled us to view programs where the sound would otherwise be muffled or the background music tended to dominate voices.

Now it is only occasionally that we comment that the production sound mix was less than optimum. Yes headphones are isolating but the sound can be kept at a comfortable level to suit the individual which is much to be preferred rather than having the TV's speakers blasting out in order for us to understand the broadcast.

A TV is an audio-visual device. Unfortunately style and the desire to have the thinnest screen possible has put paid to common sense and hence the sound becomes a compromise.

Richard Kerr,
Millfield, NSW.

Headphones are the answer

I concur with your reader who complains of poor sound on his flat screen LCD TV. Here in the UK, the model I bought last year was a Samsung LE32B551 81cm LCD. The downfacing speakers give mediocre quality. It does have analog stereo outputs which, according to the manufacturer, "connect to the audio input jacks on your amplifier/home theatre". Is this model and larger Samsung TVs not available in Australia?

The manufacturer's specification does not give the full technical details (a common failing these days) but my oscilloscope test shows typically 1V peak-peak with a 47kΩ load and a good clean analog waveform at normal listening levels.

As I'm somewhat hard of hearing, there are several options. Just turning the volume up is uncomfortable for my wife. However, plugging high-quality 32-ohm stereo headphones into the headphone socket, whilst producing wonderful rich quality sound, cuts out the loudspeaker (sorry wife!) and trails a lead across the room.

Connecting good-quality powered PC speakers, (must have high input impedance, say >47kΩ inputs) to the said audio output RCA phono sockets is a big improvement but disables the TV volume and mute controls. However, if you don't select "external speakers" there is still the output at the RCA sockets but the internal speakers can then produce delay or echo effects!

A third option is to use stereo wireless headphones but can you can find a transmitter with RCA sockets and high input impedance?

The retail box details are generally useless and manufacturer's websites similar. Using the volume on the headphones is one solution but there is no mute, as the TV Audio Out is in the "raw" pre-conditioning circuitry. I suppose removing the headphones from one's head suffices!

Robert Gott,
West Yorkshire, UK.

Practical solution to poor TV sound

Further to your reader about his flat screen TV with terrible sound (Mailbag, July 2010) I was in the same position. I removed the back of my Soniq 81cm flat panel TV and found that the speakers are easily accessible (10W 8Ω 120 x 40mm). No wonder the sound is so poor.

I disconnected the speakers and soldered on longer leads which I bought out the rear of the set through existing ventilation slits in the rear cover and connected them to a pair of 6-inch speakers in sealed boxes. The sound was much improved. I now have the TV directly connected to my old-fashioned hifi speakers (90-litre sealed boxes with 12-inch woofers, midrange and two tweeters) and the sound is terrific.

Frank Chapman,
via email.

LCD TV sets are too bright

Your latest Publisher's Letter "Today's TV – Brilliant Pictures, Mediocre Sound" is of interest, however, my wife has a very different problem. We have two Samsung LCD TV sets and she complains of glare to the extent that she cannot watch either set for an extended period. In fact, one set is back in its box having had only one week's use.

I have tried task lighting near the screen, leaving the main room lights on and turning down the brightness, contrast, backlighting and picture sharpness to varying degrees in the on-screen menus. No joy from Samsung either. Seems that the softness of CRT monitors has gone forever. Would it be possible to flash the firmware perhaps or insert some in-line attenuators to degrade the picture?

I have just about given up. My wife did have an eye test. All was OK except for very minor cataracts. The optometrist could only suggest yellow tinted glasses but these didn't help either.

I should mention that she doesn't complain about her laptop screen. It seems to be an inherent problem that I can't find an answer for. I wonder whether anyone else has come across

Some flat panel TVs do have analog audio outputs

I read your editorial and the letter from Bruce Piper in the July 2010 issue of SILICON CHIP regarding the lack of analog audio outputs from flat panel TVs. Unfortunately, Bruce bought the wrong TV.

After a lot of research into TV specifications, I recently purchased a Sony KDL 40EX700 40-inch FHD LED 100Hz set. Apart from a wonderful picture and all of the other bells and whistles you could wish for, it does have analog audio output (variable or fixed) as well as a headphone jack (on the edge). I have tried these out and they work well. In addition, it has a digital audio output (optical).

I agree that the rear-facing speakers leave a lot to be desired (especially on the high notes if any curtains are behind) but the option is there to do something about it on this TV.

I do not know if all Sony models have these outputs but I can certainly recommend this model. I am delighted with it except for the fact that it does not have a printed User Manual – opting instead for an i-MANUAL. Nothing is easier to use than a printed manual – I guess this is a sign of the times in penny-pinching.

Earlier this year I bought a Panasonic DVD Recorder (DMR-XW450). The large 119-page user manual is a great example as to what should be supplied with an expensive and complex consumer electrical product.

Ron Mills, VK5XW,
Rosslyn Park, SA.

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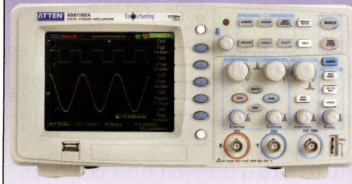

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Google Earth images out of date

I feel I have to answer to Bruce Wilson's Letter in the August Issue regarding his accusations of Photoshop manipulation of boat show aerial photos.

Firstly, I would sincerely doubt that SILICON CHIP would have the financial resources to secure real-time satellite images of Sanctuary Cove and even if they did, most of those resources are looking at more important things (like terrorists, nuclear heat blooms etc).

Secondly, the images in Google Earth are so old and out-dated that I prefer to use Neo Earth. At least the images there are a lot more recent, even if they do not yet have the down to ground resolution.

I lived in a small town in rural Queensland for over four years with a very distinctive work vehicle and in that time, that vehicle was parked outside my home every day. As yet, that vehicle has yet to appear in any of the available images! I also built an extensive workshop onto that property and it has also yet to appear in the Google Earth images.

Like the TV, don't believe everything you see on the internet and never make accusations you cannot back up. Good on yer Kevin. The majority of us were very impressed with your informative article, keep up the great work.

Dave Sargent,
Maryborough, Qld.

Comment: good theory – but the boat show photos were taken from a helicopter. By the way, at certain heights, Google Earth actually shows the date the image was shot. Zoom in to, say, 10km or lower "Eye alt" (shown bottom right of screen) and in the bottom left corner you should see "Imagery Date: (Month:dd:yy)"

the problem and perhaps can suggest an answer?

Alan Greaves,
St Clair, NSW.

UHF remote control extender has design flaws

With regards to a circuit that appeared in Circuit Notebook for July, namely the UHF link for a remote control extender, it should not be used due to two design flaws.

First, the output of the TSOP 4136, as with most IR receiver/decoder chips, is high when not receiving an IR signal. With some brands of UHF Tx module, a high of more than about 0.8V will cause the unit to constantly send out a 433MHz carrier signal. This constant signal will cause interference to all other UHF devices within range. This interference will effectively "jam" these devices. Some 90% of vehicle keyless entry units work on 433MHz. Wireless alarm systems use this frequency as do the new wireless energy monitoring systems.

Remote garage doors and gates also use 433MHz along with many other devices and all could be rendered non-operational if within range of this circuit. Some UHF transmitter units can have ranges in excess of 1km.

Flaw 2 is in the receiver. If a constant 433MHz signal is received by the receiver, its on-board AGC system will be attempting to compensate for the steady signal. This will mean that when a wanted pulse train is received, the AGC will stop the receiver from working correctly until it settles on the now correct signal.

Although the general idea has merit, this circuit should not be used for this application.

Jeff Monegal,
North Maclean, Qld.

Substitute Sanyo transistors

In the Ask SILICON CHIP pages of your July edition a reader, S. M., was asking for advice on alternatives for two Sanyo transistors. If we give the devices their full part number then they would read 2SD330E and 2SB514E and data sheets in PDF format for 2SD330 and 2SB514 are available at **www.alldatasheets.com**

Entering these latter two numbers into the NTE Electronics cross-reference database gives NTE152 and NTE153 respectively. Farnell Electronics carry NTE products and the NTE152 has a part number of 4428043 and the NTE153 a part number of 4524238. Both items are reasonably priced and are currently in stock.

My thanks for the content of your magazine. As a sole service technician, it helps me to keep up to date with new trends and devices.

Murrey Gedye,
Christchurch, NZ.

Other replacements for Sanyo transistors

In regards to S. M. of Tea Gardens, NSW and his note about Sanyo power transistor substitutes, the transistors he is referring to are 2SD330E & 2SB514E. These are a complementary

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push-pull pair in TO-220 packages.

These can easily be replaced by TIP31A & TIP32A transistors respectively. They have the same TO-220 package and the same pin-out. Both devices are cheap and readily available at Jaycar Electronics.

Kent Martin,
West Footscray, Vic.

Audio quality on commercial long-distance flights

Having flown recently from Heathrow to Brisbane return with Singapore Airlines on the A380 via Changi airport, I initially looked forward to the experience. Over the years I've flown on 707, 747 and 777s with varied experiences of the entertainment systems. While the A380 was considerably quieter and the audio/video system greatly improved, using the airline's standard headsets degraded the audio quality. Engine noise still intruded, especially towards the rear of the aircraft; obviously tourist class.

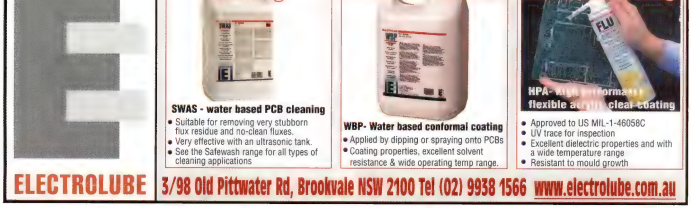
I took the liberty of "borrowing" a headphone set (fear not, they will get them back!) to trace out the circuit. The plugs of the twin stereo connector go separately to each moving-coil headphone measuring 300Ω, therefore one assumes about the same impedance. There is no common connection or series resistor. Unlike high-impedance headphones of 10kΩ for valve amplifiers or 8Ω for transistor circuitry, the aircraft unit could be described as medium impedance.

Why the fully isolated circuits? Are they commoned at the seat sockets? The question is asked because if one uses one's own headphones, noise cancelling (NC) or not, the supplied "aircraft adaptor" and/or headphones invariably commons the output. It has to because retail headphones have three poles; left, right and common using a standard miniature jack plug.

More unanswered questions! Using the said adaptor, what happens if a reasonable quality 8Ω headset is plugged into the seat socket? Will it damage or overload the aircraft system? What will be the sound level and quality? Trawling the Internet, it appears that most NC headsets which use an internal battery are of 32Ω impedance; roughly a tenth of the impedance of those supplied on-board. Again, does this impedance mismatch affect or degrade the system? What about the common connection?

Hopefully, when flying the same route in 2011, I'm intending to purchase a reasonably-priced NC headset. Fujikon NC-2 (32Ω) look modestly priced and are well-recommended.

Alternatively, I could use existing high-quality stereo 8Ω headphones and build a simple impedance matching/isolating "plastic box." The latter would incorporate two typical miniature Jaycar MM2530 transformers, 500Ω centre-tapped primary, 8Ω secondary, 450mW. Two suitable short flying leads with mono plugs to the primaries plus a miniature stereo socket with commoned secondaries as output would also be required.



Mechanical Design

Mechanical engineering is so complex it's more like an art form

RSDC: Rolling Stock Design Consult; rsdc_industrial@yahoo.co.uk

Case History No.71

Even though we spend a lot time designing railway carriages, we also supply Mechanical Design consulting service to the military, electronics, process and vehicle engineering markets. Going back into our archives I hope to be able to help you understand the subtle issues that make your use of mechanical design more of a success then it might otherwise have been.

We were called in by an old client who had bought some (120) stainless cabinets off an importer because they were "cheap". His company manufactured monitoring equipment to the process industry and he saw these cabinets as ideal for some of his standard monitoring equipment. One of his regular clients owned a variety of plants all over the country and he had sold all 120 cabinets as a job lot after fitting them out with his equipment. Unfortunately about 60 of these cabinets had experienced severe corrosion after 3 months service and my old friend was looking down the barrel of a very expensive warranty claim.

The stainless shelf had corroded around the inside shelf area and to make matters worse about half of these also experienced very severe corrosion of some aluminium brackets which tied some of my clients equipment together. Working with stainless as we have with almost all of Sydney's double deckers, our company's expertise in the use of Stainless is considerable. I inspected one those cheap cabinets and immediately saw the flaw.

Stainless steel uses oxygen as part of its "built in" protection system. Some forms of sheet metal configuration starve some areas of oxygen and the metal simply falls apart. My client's only option was to replace all 120 cabinets with a design that suited the application. We talked him out of using stainless in favour of a zinc-coated mild steel which, in our opinion, best suited the environment that his client was experiencing in his plants and it was also cheaper.

We jumped a domestic flight to visit the 60 units that had internal alloy corrosion. It transpired that this big multi-national had fitted my clients monitoring equipment near some of their equipment which contained a microswitch which contained mercury. Due a faulty design, their switches had fractured and were leaking mercury vapour into the air, causing my clients alloy to literally "turn to powder" because mercury actually "melts" aluminium. My client made a warranty claim against the multi national, based on our report. All 120 units were returned to "have the alloy replaced" . . . but also managed to replace the stainless cabinets in the process. He structured his claim against them to cover some of his costs but threw in his profit on the original deal. That way he wasn't bankrupt but had forgone his profit which he considered a safer option.

At least he didn't have to foot the complete bill to replace all the stainless units because that would have cleaned him out completely and this allowed him to live to fight another day.

Peter Walker: 0450 117 360 rsdc _industrial @ yahoo.co.uk

NATO supplier code: KD3TF

Mailbag: continued

Is it worth going to this trouble? I'm travelling Qantas next year. Any advice much appreciated.

Robert Gott,
Normanton, West Yorkshire, UK.

Comment: we don't know the answers, Robert. Perhaps a reader can comment.

Digital scopes don't give a realistic picture of analog signals

I have a comment regarding your editorial and the Air Quality Meter article in the June 2010 issue. The console style gas space heater which we have had in our lounge room for over 20 years has a "concentric" powered flue. As well as the exhaust gasses being vented outside, the intake air for the combustion process is drawn in from outside through the same flue. This keeps the combustion cycle completely separate from the room, with only the heat generated being conducted to the room via a heat exchanger and fan. I find it a bit strange (with the exception of the "plug-in" style portable gas heaters), that all gas heaters are not required to have the same flue system as our heater has.

The glowing review of the LeCroy WaveAce digital scope has goaded me into commenting on this and digital scopes in general. Despite all the wonderful features these scopes have, I regard the trace displayed on the screen as being so poor as to be almost useless. Looking at the pics you have published, I ask how can anything really useful be gathered from the pathetic fuzzy jagged waveforms displayed on the screen? Are those, I presume, sinewaves in your pictures, really pure sinewaves?

If you suspected, for example, that an audio power amplifier had crossover distortion, it would be impossible to see it on the screen. If there was a small "bubble" of parasitic oscillation on a waveform, it would be virtually impossible to see it just by examining the display. Could you accurately calibrate the HF compensation on a x10 probe? I don't think so. The "corner" of the square wave used to adjust for no undershoot or overshoot would be too fuzzy and unstable to make reliable adjustments.

At my work recently, I was commenting to a colleague about how the sine shapers in many function generators have noticeable distortion on the waveform peak, resulting in a small point instead of a smooth rounding. To demonstrate this I hooked the output of a FG to a CRO. Ooh, it was a digital scope. After spending some minutes trying to discern the point on the waveform top, I gave up! The noise and garbage completely masked what I was trying to show. I later dragged an old cheap analog CRO in and was able to show the distortion perfectly!

On another occasion, I had the output of a sinewave generator feeding into a digital scope and I was slowly increasing the amplitude. At one point, the display on the scope started to clip. There was no reason why the

More bad feedback on compact fluoros

I was interested in Ray Hudson's letter, Mailbag April 2010, as his observations are similar to mine. None of our CFLs have given their claimed life. They are mainly used in oyster fittings to reduce the fittings' internal temperature which was very high using conventional incandescent globes. I suspect that higher internal temperatures in the fittings may contribute to their shortened life.

The failure of his 18W fluorescent lights (assuming they are hot-cathode types) in his bathroom would most likely be due to constant on/off switching. Fluorescent lights have a finite number of switch-on cycles and will quickly fail if used in this way. Also, when used in bathrooms, the time for them to start can be a nuisance, particularly in cold weather. Another thing against bathroom use is poor colour rendition, important if a vanity unit is incorporated.

Fluorescent lights are best used when they are only switched occasionally, with a long "on period". Because of this characteristic, they give their longest life when used in say kitchens or in commercial and similar premises.

As some people seem displeased with the life from their CFLs, I wonder if CFLs also suffer from this switching characteristic.

Brian Coulson,
Balcolyn, NSW.

input signal would be clipping and as I increased the amplitude further, the clipping disappeared. Winding the amplitude up and down showed that this "clipping" was not signal clipping at all but just one of the bad quantising characteristics of the digital scope.

The scope was a comparatively cheap one, so I went and got a better Tektronix model. Although it wasn't as bad, the flattening of the waveform peak was still noticeable at various amplitude levels. Can these scopes be trusted to give an accurate display? Definitely NOT!

I was talking some time ago with a couple of technical officers who worked for a company which specialises in reconditioning and recalibrating high-end, secondhand test and measurement equipment. When I mentioned digital scopes, these two fellows said that their company gets phone calls every week from people wanting high-end reconditioned **analog CROs** because the digital scopes, even top-quality ones are just too poor in what they display!

Perhaps it's time you reviewed some good analog CROs, showing just how pure and clean the display is even if they don't have all the bells and whistles that the digital ones have.

Ray Chapman,
Senior Technical Officer,
Pakenham, Vic.

Comment: as always, there are two sides to the story and those noisy traces you are complaining about may actually be a truer representation of the signal. In other words, maybe that noise is really there. Analog scopes effectively "average out" that noise to display a clean waveform.

You can often get the same result on a digital scope by using the "averaging" mode.

However, where there a lots of

Cost breakdown on CFLs

Last year I decided to replace some of my household light bulbs with compact fluorescent types to compare the durability. One of the bulbs was installed in a fixture that is on approximately six hours a day. The existing bulb was 75W and to achieve a compatible light output, I installed a 23W compact fluorescent, with a life rating of three years.

Six months after being installed it failed. I thought I had a dud unit, so replaced it with another 23W unit but a different brand. Nine months later it also failed. The fine print on the package states that three years is calculated at 5.5 hours/day, ie, about 6000 hours. So, my two bulbs lasted 6 hours x 183 days (or about 1100 hours) and 6 hours x 274 days (or 1645 hours) – nowhere near the supposed life of these units. These bulbs may use less energy but they are expensive, don't fit many light fittings and it seems, are not as durable as quoted.

I think Halogen replacement is the way to go.

Rob Leplaw,
Oatley, NSW.

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Making your own 3D movies

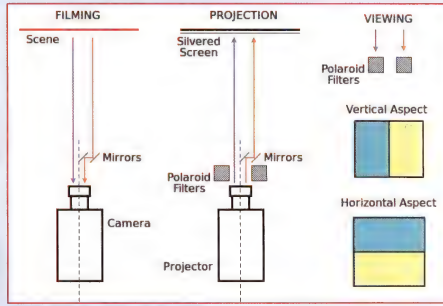
The recent articles on 3D TV and in particular, the article on the SpeedWedge in the June 2010 issue, prompted me to write.

Nearly 30 years ago, I made my own 3D movies to wow friends and family. The principle was simple and should transfer to modern digital technology as is.

Two mirrors split the same image into two, side by side on film (see the FILMING diagram and the Vertical Aspect diagram). The film was then developed. With two similar mirrors (see the PROJECTION diagram), these two images were projected on top of one another onto a silvered screen. Each image was projected through an oppositely polarised Polaroid filter.

The audience then viewed the movie through oppositely polarised Polaroid spectacles. The silvered screen ensured that the polarisation of the two images was not lost.

The aspect ratio of the final 3D picture was vertical (again, see the Vertical Aspect diagram), as a horizontal aspect ratio would have required a more complex system of mirrors to fit two panoramic views on standard film (see the Horizontal Aspect diagram) and then to project them on top of one another on the silvered screen.



In fact, if the audience is willing to squint, all this could be done without the silvered screen, without the polarised filters and without the second set of mirrors. As an example, you can try it with the above photos that I took of a Church's bell-tower in Laaiplek, a town 160km north of Cape Town in South Africa. One needs to go cross-eyed and when the two images snap together, bring them into focus.

Rev. Thomas Scarborough,
Cape Town, South Africa.

glitches and irregular waveforms, averaging cannot be used and you have to put up with apparently noisy traces. On the other hand, the analog scope will just not be in the hunt.

Is the heavily noise-filtered trace on an analog scope actually a true picture of the signal you are looking at? Digital scopes may indicate that it is not.

Some years ago we felt the same way about digital scopes but as you become more familiar with today's high-performance units, you will realise that going back to an analog scope is a retrograde step. SC

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FUSION audio/visual equipment for boats

Boaties like to have access to radio, music and on larger vessels, video. Whether they are cranking the music up on the long run to fish the continental shelf, relaxing at anchor or keeping track of weather reports, they want performance and state-of-the-art gear.

Today, most boat-builders have receiver/amplifiers as original equipment or as an option. In fact a $4.6 million motor yacht at the recent Sanctuary Cove boat show had a FUSION sound system in every cabin, the flybridge and transom area for totally independent listening.

Marine systems with an integrated DVD player are relatively new, however FUSION's 600 DVD model also offers iPod control and replay, plus FUSION has a world's-first unit with weatherproof iPod dock and controls built-in.

We saw the FUSION 600 DVD model at the recent Sydney Boat Show – and like many boaties, we liked what we saw.

But it was only when we "lifted the lid", so to speak, that we were impressed enough to tell SILICON CHIP readers about it too!

With an in-built iPod dock, it handles programs from any conceivable audio source: DVD, CD, MP3 and all audio units with a headphone socket or RCA line-out. If an iPod is plugged into the dock, the MS-IP600 takes over the controls of the iPod and also charges it.

Designed for marine use

FUSION's 600 series audio/visual entertainment unit, examined here, is designed specifically for marine use; it's not just re-badged car equipment. They are probably the only company in the world who design true marine entertainment systems from the ground up.

FUSION gear is designed in Auckland, NZ for worldwide distribution – and is taking off in Australia and the United States.

Class-D for efficiency

One problem with entertainment systems on most boats is that mains power is not available.

Instead, power comes from batteries and to keep batteries charged, you either need solar panels and/or you have to run the engines or a genset.

For the batteries to last as long as possible, the current drain of audio equipment needs to be as low as possible.

FUSION were one of the first marine entertainment manufacturers to employ Class-D amplifiers, which have typical efficiencies of 85% or more – a great improvement on that achieved by Class-AB amplifiers. Incidentally, that's one reason that the vast majority of portable audio

by Kevin Poulter

equipment and cheap home theatre sound systems now use Class-D. Class-D amplifiers also mean much more compact construction, which is why the small FUSION range can produce lots of power.

Another big advantage of Class-D is that it doesn't need a lot of cooling. Some brands using class AB amplifiers provide cooling with a large hole in the rear and a computer fan. This inevitably draws in salt air.

True 360° waterproof design

No other environment is as unforgiving as the marine environment. Predominantly moisture-laden salt-concentrate (also called 'fog' in the marine certification tests), is a relentless invader attacking metal parts with gusto.

This can be combatted by sealing all entry points, which is only possible if you have used class-D amplifiers.

The 600D series has a die-cast clamshell construction, with a single lid and a rubber gasket, plus two sealed compartments to totally seal it from the elements.

FUSION's 600 complies with IP-x5 splashproof standards. The rugged diecast 'clamshell' construction withstands the harsh marine environment, including the pounding and vibration a vessel normally experiences.

What makes it tick?

Taking the cover off and removing the DVD player reveals a digital tuner, audio processors enabling zone control, plus a number of building blocks making up the product.

As already noted, the 600 platform is quite powerful, delivering 4 x 70W (peak) into 2-ohm loudspeakers from its bridged amplifiers.

Multi-zone technology

Zone control is particularly important in larger motor yachts as it makes it easy to access and direct audio all over the boat at the level required in that particular area.

Flash memory

It is normal safe practice when a boat is unused (eg, tied up at a mooring or berth) for all batteries to be isolated, via master switches or circuit breakers.

Therefore no power is available to maintain memory settings, as it would be in a car, for example.

FUSION get around this by storing all last-used parameters in non-volatile memory. Even if the boat is not used from one year to the next, when the FUSION 600 is turned on all settings will be exactly as they were before.

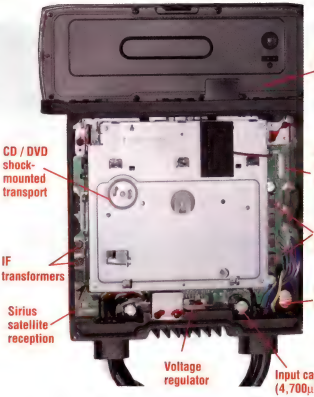
ARM processor.

The user interface has been designed to be as simple as possible to operate. To achieve this, the heart of operations is an ARM processor with a 32-bit Reduced Instruction Set Computer (RISC).

One benefit of the ARM processor is that it is very suitable for low power applications.

More intelligence

When you adjust the backlight of the LCD for night use, all the keys are mapped, so they also change brightness proportional to the screen illumination setting. The display digits are large and the digital clock is about 25mm high.



Apple iPod interface

Through the iPOD interface which FUSION developed, it communicates with the iPod and can interrogate it, read files and track information, plus search it.

Since Apple do not usually give away the technical ability to search for music, FUSION developed their own alpha-search technology. It means you can find music in a vast array of songs or albums effectively.

In order to be Apple-approved equipment, FUSION submits their prototype hardware to Apple for extensive testing and ultimate approval, before it can be released to the market.

No manual required!

In the FUSION there is no multiple-lines-of-text-on-screen that require a user manual that's the size of a book; in fact, it's so intuitive that a user manual is obsolete. Inspired by the way Apple do things, FUSION makes their products very user-friendly, through icons and simple key-presses.

Sirius satellite reception ready

In addition to AM/FM reception, this model can receive Sirius Satellite Radio in USA and Canada via optional equipment – important to skippers of larger vessels who travel to North America. Sirius Satellite Radio provides 69 streams (channels) of music and 65 streams of sports, news and entertainment to listeners.

Specifications:

Power Output:	4 x 70W max; 4 x 43W RMS into 2Ω
Media:	AM/FM Tuner; Sirius radio ready DVD/CD, MP3 and iPod (also available with internal iPod dock)
Outputs:	1 x RCA stereo, 2 x subwoofer, video & S-video
Inputs:	iPod, RCA auxiliary, Sirius, wired remote
Display:	2.7-inch backlit LCD
Waterproofing:	IPX5 (includes full behind-dash water protection)
Dimensions:	80 x 217 x 36mm (mounting 53 x 181 x 160mm)

Conclusion

If the response by visitors to the boat show is any indication, FUSION, a small NZ company, is leading the world in marine AV entertainment.

Further details:
Fusion, Ph: 1300 736 012
www.fusionelectronics.com

LED replacements for fluorescent lamps: are they any good?

Half the power – lots of light – more than twic

36W fluorescent tubes are the main source of light in supermarkets & retail stores, offices and many factories. There are hundreds of millions of them in use around Australia and many billions in use around the world. But while they are the most efficient light source in offices and the home, they are now being challenged by LED tubes which can directly replace them.

By LEO SIMPSON

BACK IN THE MAY 2010 issue we had a feature article on how to slash office lighting bills by using quad phosphor fluorescent tubes made by NEC. In our own office, we substituted one quad phosphor tube for the two existing tubes in each twin-lamp luminaire. The result was a much brighter office and a cut in electricity consumption due to lighting of about 50%.

Since then we have heard from readers who are delighted with the results of using quad phosphor fluorescent tubes. In one industrial warehouse complex, they replaced all the tubes in what was a dingy and dangerous underground section and the increase in lighting was a revelation. In that case they did not save power but the improvement in illumination, especially at night, made the complex much safer and less prone to graffiti and vandalism. As a bonus, the improved lighting also made their CCTV security system much more effective.

At the end of the above article, we made a brief reference to the existence of LED replacements for fluorescent tubes but discounted them at the time because they were very expensive and the units that we knew of apparently did not comply with Australian standards. We concluded with the remark that "In the next few years that is bound to change."

Well, the future has a habit of arriving quickly these days. In the very next issue (June 2010), local company Tenrod Australia introduced a range of ecoLED replacement tubes. Naturally, we had to obtain some samples and put them to some comparative tests.

The first point to make about these LED replacements is that they are exactly that. They can be fitted in place of conventional fluorescent tubes since they have the same length and the same 2-pin connector at each end. There are a number of provisos though. First, while they can be used in standard 36W fluorescent fittings which have a conventional ballast, the starter MUST be removed. **If the starter is left in place, it is immediate death to the LED replacement tube.**

Ideally, the fitting should be rewired so that the ballast, starter and power factor correction capacitor (if fitted) are all removed, to provide maximum efficiency. In effect, the full mains supply is applied across the LED replacement tube.

This close-up shot of the end of a LED replacement tube shows the different LEDs used in the Cool White model. It is apparently powered as four sets of 63 LEDs.

The tubular extruded aluminum housing provides rigidity and acts as a heatsink. It barely gets warm.

If the existing iron ballast is left in place, there is a small loss in efficiency but since the extra power consumption amounts to less than one watt, we think that most users will leave the ballast in place. It is too much trouble to remove it.

LED replacement tubes cannot be fitted in fluorescent fittings with electronic ballasts, unless of course, the fitting is rewired to remove the ballast.

How many LEDs?

The ecoLED T8 replacement is housed in a tubular aluminium extrusion with a clear polycarbonate lens section. It has three rows of 84 LEDs each, making a total of 252. The LEDs are surface-mount types, on a long narrow PC board. The driving electronics is in the tube housing.

Switch on a LED replacement tube and there is a short delay of about two seconds and then it lights up at full brilliance. There is no flick-flick-flickering and no gradual build-up in light output. There is no strobing which can be evident with conventional fluorescent tubes and nor is there any buzz, hum or whistle. Radio interference is also very low.

And they are really bright. Looked at directly from less than a metre away, they are almost painful to behold. The aluminium tubular housing barely gets warm and that is what you would expect since the power consumption for the tube is around 20W or less – less than half the consumption of a fluorescent tube running with a conventional ballast.

Looked at from further away, their apparent surface brightness is also higher than any conventional fluorescent tube. However, that is not the whole story. While, the LED replacement type radiates mainly in one direction, set by the individual LED lenses, a conventional fluorescent tube radiates evenly in all directions around its main axis and so puts out more light. This may or may not be useful, depending on whether the luminaire has a reflector behind the tube and maybe a prismatic diffuser in front of it.

For example, we did some comparisons between a Daylight White LED replacement and an NEC quad phosphor 36W fluorescent tube. The

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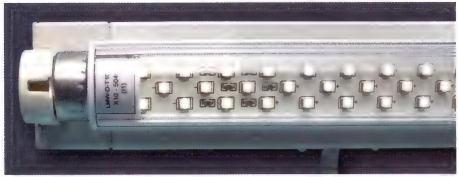
These LED replacement tubes are exactly the same overall length and use the same 2-pin connector as on standard T8 fluorescent tubes.



This is the Daylight model in which the surface-mount LEDs are all the same type and colour.

light fitting was a single 36W batten with a conventional iron ballast and no reflector, mounted on the ceiling of a small study measuring about 2.5 x 3.5 metres. Comparative light outputs were measured by a Digitech multimeter with a Lux scale. It was sited on a desk 2.2 metres below the light fitting.

Brightness

When first turned on, the LED replacement produced a reading of about 138 Lux which was certainly adequate for general tasks such as reading or using a computer. However, since most of the light is projected straight down, it was noticeable that the ceiling itself was quite dark, as you might expect from the tube's 120° viewing angle. The overall room illumination improved when the prismatic diffuser was fitted, as this bounced some light onto the ceiling. It did not make any difference to the Lux reading though.

The second test was with the NEC quad phosphor tube and this produced a reading of 215 Lux. Not only was this 55% brighter but the illumination was more even, with considerable bounce of light from the sides of the tube off the ceiling. Fitting the prismatic diffuser made a slight difference, increasing the reading to 220 Lux.

On the face of it, the NEC quad phosphor tube wins the light output race by a mile but there is a lot more to the story. On the other hand, if we had used a single phosphor tube the comparison would have been in favour of the LED replacement. However, we did not see much point in that. Since the LED replacement has a premium price it should be compared with a premium fluorescent tube – the NEC quad phosphor.

As an aside, the LED replacement comes on with full brilliance and then dims very slightly as it warms up over a period of (say) 30 minutes. The dimming is so slight that you only know about it if you are measuring Lux – otherwise it is not apparent. This is in line with normal LED behaviour – the warmer they are, the less light they emit but it is not a large effect.

By contrast, the quad phosphor tube started off with a relatively low output (it was a cold July evening with a room temperature of about 12°C) and came up to full brilliance in a period of about 30 minutes.

As far as power consumption is concerned, the LED replacement wins hands down, with less than half the power use of a conventional fluorescent fitting.

By the way, when installed in a fitting with a prismatic diffuser, these tubes appear little different to ordinary fluorescents, at least to the casual observer.

How it works

The Tenrod LED replacements are powered by an internal switchmode supply. It can accept a mains input supply from 80-265V AC. It has an EMI (electromagnetic interference) filter at the input followed by a bridge rectifier and capacitor filter. The supply is based on a PFM (pulse frequency modulation) chip and a Mosfet which regulate the current though the LEDs to within 5%. Hence the LED brightness is essentially constant for that full range of mains input voltage.

In fact, we measured the brightness over the range 70-250V and there was virtually no variation at all. One thing's for sure, with these tubes "brown-outs" will be a thing of the past.

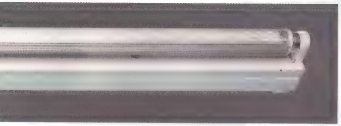
The LEDs in the Tenrod tubes appear to be run in groups of 63 (4 x 63 = 252), possibly further split into three paralleled strings of 21 LEDs. This would give an operating voltage in the region of 70V and is in line with the minimum input supply of 80VAC. Mind you, we are hypothesising here because we were not able (unwilling, actually) to break into the package to find out the details.

Power consumption was virtually constant over a fairly wide range of mains input voltages. For one of the sample tubes we tested, in a fitting without a ballast, it was 19.6W at 210-250VAC. Power consumption drops very slightly after the unit has been running for 30 minutes or so.

The Tenrod LED tubes come in three colours: Daylight White (5600 - 6300K), Cool White (3800 - 4200K) and Warm White (3200 - 3500K). Their brightness ratings were 400, 375 and 360 Lux, respectively (measured at a distance of one metre). Total light output, measured in Lumens, was 1500, 1400 and 1350, respectively.

For the Daylight tube, that is equivalent to 75 lumens/watt which compares very favourably with the NEC quad phosphor tubes at 100 lumens/watt.

Interestingly, on a Lux/watt basis, the ecoLED Daylight tube easily beats the NEC quad phosphor, especially if it is fitted in a ballasted luminaire.



For our money, we would go for the Daylight model for most applications. The different colours are obtained by mixing the LEDs in the rows but for the Daylight White the LEDs all appear to be the same – white.

OK, so we have talked about light output and power consumption. A number of points remain to be discussed. The first is expected life. Typical fluorescent tubes have a stated life of 16,000 hours and can be expected to last four or five years in a typical office installation. This is far in excess of compact fluorescent lamps which often don't last any longer than the much-maligned incandescent lamps.

The above-mentioned NEC quad phosphor tubes have a 20,000 hour life but these ecoLED replacements have a stated life of 50,000 hours!

Such a long life makes them ideal for installations where they are on permanently, such as in parking stations and railway stations. They could be expected to last almost six years. In practice, no-one really knows how long LEDs last so they could have an even longer life.

As an aside, the fact that they work well at low temperatures means that they can be used where conventional fluorescent tubes don't function efficiently and have difficulty starting, such as in freezer and cool-rooms and in glass-fronted refrigerators (as in supermarkets and convenience stores).

How much are they?

The final point is the price. As you might expect, these ecoLED tubes are significantly more expensive than even the NEC quad phosphor tubes we cited as a benchmark. But with less than half the power consumption and very long life, many building owners will be looking very closely at installing these tubes.

Pricing for the Daylight T8 tube is $80 + GST on a one-off basis, dropping to $60 + GST for 100-off quantities. With electricity prices rising inexorably, they are certainly attractive, especially in installations where they run 24 hours a day. At 24c/kilowatt hour (the Energy Australia commercial rate) it costs $100.92 to run one 36W ballasted fluorescent fitting (drawing around 48W total) for a year. By using an ecoLED tube drawing 20W instead, that drops to $42.00. You don't have to be a chartered accountant to work out that an installation of these tubes into a parking station would have a very short payback period.

Oh and we should mention that these LED replacement tubes have no mercury and no lead content. Our impression is that these LED replacement tubes will make very quick inroads into the Australian market and around the world.

For further information, contact Tenrod Australia Pty Ltd, 1/24 Vore St, Silverwater, NSW 2128. Phone (02) 9748 0655. Their website is at **www.tenrod.com.au** SC

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dick smith
Talk to the Techxperts

Designing and Installing a HEARING LOOP For the deaf

Many people have hearing impairment. Whether they are watching TV, listening to radio or music, attending a concert, meeting or religious service, they have difficulty hearing, or understanding, what is going on – and that may be in spite of using a hearing aid. Hearing loops, which inductively couple an audio signal to a hearing aid, are an increasingly common method of helping ease that difficulty.

Just because you have a hearing aid does not mean that your hearing problems are solved. When you have normal hearing, your ears are very good at discriminating between noise and the sounds you want to hear. Not so with a hearing aid, particularly if you are wearing only one.

The hearing aid is basically a microphone, amplifier and earpiece. Unfortunately the microphone picks up all sounds and noise then amplifies all by the same amount. The wearer often has great difficulty discerning what is going on.

In many situations this problem can be largely overcome by a hearing loop, fed by an audio amplifier. The loop is placed around the room or hall and the radiated signal is then picked up by a hearing aid fitted with a T-coil (or Telecoil; see the sidebar, "The origin of the Telecoil").

Alternatively, the signal can be picked up via a Cochlea implant or even a loop receiver, as described elsewhere in this issue, driving conventional headphones/earbuds.

Hearing loss increases with age so it is common for hearing loops to be used, for example, in halls and places of worship which older people frequent. In fact, many modern buildings are so equipped these days.

In the home, of course, the problem can be just as difficult, especially when shared with those without hearing impairment. But it is unusual for hearing loops to be installed in the home.

Until now, that is: in this article we describe how to set up a basic hearing loop for the home or for small to quite large meeting rooms, to Australian, New Zealand and IEC (*International Electrotechnical Commission)* standards – and how to drive it.

This could be done using a commercially made amplifier specifically intended for hearing loop applications but equally could be a standard commercial amplifier or even one of the many amplifier designs published by SILICON CHIP.

Professional hearing loop installations can cost many thousands of dollars, especially when retro-fitted (most new public buildings these days have them installed during construction in appropriate areas as a matter of course).

Part 1: By JOHN CLARKE

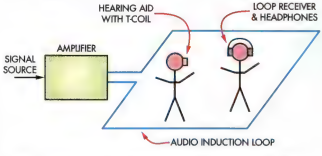


Fig.1: the basic arrangement for a hearing loop. Signal from the room PA is amplified and coupled into the loop. The resulting magnetic field is detected by suitably equipped hearing aids or receivers.

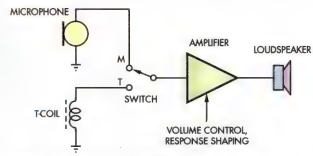


Fig.2: a hearing aid equipped with both T-coil and microphone to cover both signal sources. Many hearing aids will have a switch to select both. Obviously, the loudspeaker is tiny enough to fit in the ear.

However, a do-it-yourself installation along the lines set out in this article can provide excellent results and save a heap of dollars. It is relatively easy to fit and can be made small or quite large, depending on the area needed to be covered.

What's a hearing loop?

In its simplest form, a hearing loop system comprises a signal source, an amplifier and a large loop of wire around the room or hall. As this loop forms a coil with an AC current flowing through it, it radiates an electro-magnetic wave which is in sympathy with the signal source.

This radiated signal can be detected by a hearing aid equipped with a T-coil or indeed, a loop receiver (with headphones) designed for the purpose. Fig.1 shows the arrangement but we will explain just how this works shortly.

If you want to set up a hearing loop in your home you should be able to get satisfactory results without any special equipment. For larger setups in halls, the magnetic field produced by the signal in the loop needs to be set to the required level, so that all hearing aids with T-coils will operate correctly.

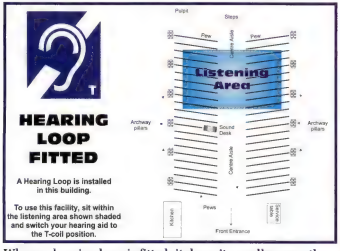
In a later article in this series we will show how to build and calibrate a signal level meter to measure signal levels from the installed loop.

Our hearing loop is suitable for use in a home, office, hall, church or similar building. We include design graphs and tables to make it easy to select the wire size and its length, along with the amplifier power requirements for a particular installation.

For large loops, say in a community hall or church, you will need a signal pre-conditioner. In a later issue we will present a suitable design to allow a standard amplifier to be employed. The pre-conditioner provides stereo signal mixing, audio compression, treble boost to provide compensation for loop inductance and treble rolloff above 5kHz.

Other articles will provide circuit and construction details for an induction loop receiver (see p62 of this issue) and a microphone loop driver.

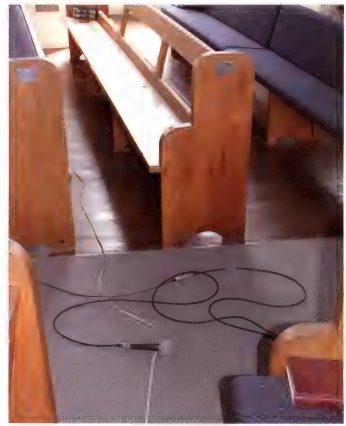
Now let's describe the basics of a hearing aid.



Where a hearing loop is fitted, it doesn't usually cover the entire area. Hence a "map" is needed, such as this one in a church, to show deaf people with hearing aids where to sit.

How does a hearing aid work?

As we mentioned earlier, in its simplest form a hearing



The hearing loop (white figure-8) is laid out here for testing before permanent installation under the floor.

A commercial hearing loop amplifier, in this case the model 1077 from Auditec. It's a current amplifier, which has some advantages in hearing loop use but standard voltage amplifiers are certainly usable as well.

aid comprises a microphone, an amplifier and a miniature loudspeaker. In normal use the sound picked up by the microphone is amplified and processed, depending on the complexity of the hearing aid. The amplified signal is then reproduced via the loudspeaker which is closely coupled to the wearer's eardrum at a level which compensates for the loss of hearing. Fig.2 shows the general internal arrangement.

Better, modern hearing aids also include signal processing to try to present the clearest audio to the wearer. And the best also include a Telecoil (or T-coil), which comprises a coil of wire on a ferrite core. A switch on the hearing aid selects the T-coil or microphone as the input source.

Originally used to couple the electromagnetic energy from a specially equipped telephone into the hearing aid (hence the name), their use has now expanded to be able to detect an electromagnetic signal from a hearing loop, where fitted. Not all hearing aids have a T-coil and obviously, without one, there is absolutely no advantage from either telephones or hearing loops.

Fig.3 shows the magnetic field produced by the hearing loop (sometimes referred to as an audio induction loop) and how this couples into the T-coil. Normally the induction loop is horizontal and the T-coil is vertical (for a person who is sitting or standing). Any variation of the T-coil from its vertical position will reduce the received signal.

There is nothing to stop the orientation of the hearing loop being vertical, allowing hearing aid wearers to use the loop when lying horizontal.

Here's a commercial hearing loop receiver which drives standard headphones. Or you can build your own: see the article on page 62!

One disadvantage of the T-coil inductor is that it produces a signal which rises in level with increasing frequency. This is because the induced voltage is proportional to the rate of change of the magnetic field and so higher frequencies will give a higher voltage. This rising response is normally compensated for within the hearing aid to produce a flatter frequency response.

So why would a person with a hearing aid prefer to listen via the T-coil instead of listening directly to the sound from a public address or similar sound system? After all, a hearing aid is designed to pick up sound, amplify it and tailor the frequency response to suit the individual user.

As already noted, people with normal hearing have little trouble discriminating between unwanted noise and the sounds they want to hear. By contrast, the wearer of the hearing aid finds that in a room full of people or in a noisy environment, all they hear is a whole lot of noise and it prevents them from following any one sound or conversation. To that you can add natural reverberation in a large room, the noise of people moving about and maybe background music.

The room, especially if it's reasonably sized, may well have some form of public address system fitted. That's fine for those with normal hearing but ironically, a PA can introduce more reverberation, cause hearing aid overload (distortion) and can raise bass levels to further muddy the sound clarity.

The solution is to channel signal directly from the public address system into an audio induction loop to be picked by the hearing aid T-coil. The resulting sound is clearer because it only contains that broadcast by the sound system and extraneous sounds from other people and reverberation are absent.

As good as it is, listening via a T-coil is not perfect: the hearing aid user can feel isolated from the rest of the group of people in the building because they do not hear the ambient sounds of the people around them.

To overcome this, some hearing aids include switching to select three options: T-coil, T-coil plus microphone and microphone only. The T-coil plus microphone setting mixes the signals to allow ambient sounds and the broadcast (PA) signal to be heard but even this can be a compromise.

There is no perfect electronic cure for deafness! Protect your hearing while you have it.

As an aside, it is widely and reliably forecast that the

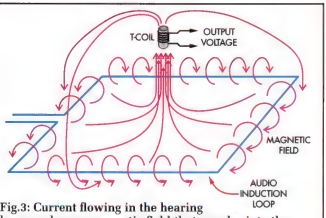


Fig.3: Current flowing in the hearing loop produces a magnetic field that couples into the T-coil. Voltage is produced across the T-coil terminals.

next ten to twenty years or so will see an explosion in the number of younger people with irreversible hearing damage, caused (in particular) by years of exposure to loud rock music (why do bands have to play so loud?) and more importantly, the massive use of ear-buds at excessive volume from cassette players, then CD players and most recently MP3/MP4 players and mobile phones.

Designing a hearing loop system

Before embarking on designing and installing a hearing loop, you need to decide whether the building is suitable for installing a loop. For many buildings the loop can be installed beneath the floor, especially if it is timber construction and there is access to the underside of the flooring. Where there is a concrete floor, the loop could be placed around the floor under carpet or behind skirting boards. Alternatively, the loop could be placed in the ceiling, provided it is not too high above normal listening level.

Installing a hearing loop in buildings made with steel frames or reinforced concrete is more difficult. This is because the steel tends to reduce the magnetic field strength. The solution may be to provide more current drive in the loop with a larger amplifier and/or by using more complex loop designs.

For most installations, a single loop is all that is needed. Loop performance can be checked before it is permanently installed by simply running the loop wire temporarily around the area (eg, on the floor) where required.

An important factor to consider when deciding on the positioning of a loop is interference from the mains power lines. In particular, phase-controlled light dimmers for stage and auditorium lighting often cause a buzzing sound, predominantly at 100Hz. The interference will be highest when the lamps are dimmed.

Fluorescent lamps can cause interference when they are switching on but do not usually cause problems once lit.

Another source of interference is close proximity to computers and monitors; in fact anything with a "switch-mode" power supply.

We'll be describing a Hearing Loop Level Meter in a future article, which can be used to check the background interference levels down to 21dB below a 100mA/m reference.

What level?

According to the Australian standards (AS60118.4-2007), environmental audio frequency background field levels

The origin of the Telecoil

Hearing aids installed with a Telecoil or T-coil began as a solution to a problem that occurs when using a hearing aid with a telephone. The name Telecoil originates from the words telephone and coil.

To understand the problem you need to be aware that there is coupling between the telephone mouthpiece and the telephone earpiece, so as you speak some of the sound is heard through the earpiece. The coupling is called side tone and is deliberately introduced to prevent the telephone sounding dead when speaking.

This can cause a problem when using a hearing aid. When it is brought close to the earpiece of a telephone, the hearing aid often produces a loud-pitched squeal, or feedback. This is caused by the microphone on the hearing aid picking up sound that is amplified and reproduced by the hearing aid loudspeaker, which is then received by the telephone handpiece and then further re-amplified by the hearing aid and so on.

To allow a hearing aid wearer to use a telephone, without this problem occuring, the telephone is modified to include a wire loop that is driven by the same signal as the telephone loudspeaker. The loop produces a small magnetic field that varies in sympathy with the signal.

To utilise this feature, the hearing aid needs to include a Telecoil (T-coil) that detects signal from the phone's magnetic field. When required to be used in this way, the hearing aid is switched to the "T-coil" position, disabling the hearing aid microphone and thus avoiding the audio feedback.

Some telephones include a Telecoil already installed within the handpiece; some may need one fitted as an accessory. More information is available from your telephone supplier or via The Independent Living Centres Australia (www.ilcaustralia.com/home)

Some hearing aids are designed to automatically switch over to the T-coil position in the presence of a strong DC magnetic field. The magnet in the telephone earpiece provides this field.

Due to the success of the T-coil in hearing aids with telephones, its application has broadened to where hearing loops are now commonly used wherever sound needs to be available for the hearing impaired.

A "behind the ear" hearing aid. The tube at the top feeds into the ear canal, fed by the miniature loudspeaker at the top of the unit. Controls on the back of the unit include a volume control, power switch and the all-important T-coil/ microphone switch.

should be below –20dB 'A-weighted' with respect to a 100mA/m reference field (or –40dB below 1A/m) using a slow (S) time weighting of 1 second.

We do have reservations about whether this level is sufficiently low for satisfactory hearing loop performance. The Hearing Loop Level Meter will also measure noise using a wider frequency response than the A-weighting provides. This can give a more realistic indication of whether noise will be intrusive.

Another consideration is whether the loop wire will be running close and parallel to signal wires in a public address system, such as for microphones. This has the potential to cause instability in the sound system although it is usually no more severe than feedback caused by loudspeaker wiring running close to the microphone cables.

Further problems may occur with dynamic, electret and UHF radio microphones and guitars with magnetic pickups. It is wise to test for these problems with a temporary loop installation. Problems will be evident if the sound seems distorted or has a "metallic" quality. An oscilloscope can also be used to monitor the sound system signal for any instability.

Note that an audio induction loop setup will not cause direct acoustic feedback, ie, the squeal associated with audio coupling of microphones and guitars to loudspeakers.

Spill

Generally, the area where a hearing aid will receive the signal is within the loop itself. Outside the loop, the signal level drops off. Fig.4 shows the measured field strength of a 10m x 10m square loop at a height of 1m above the loop. The signal is reasonably constant (to within 3dB) within the loop area but drops off just outside the loop. Any signal outside the loop is called the "spill".

Spill means that the signal is not secure and might be intercepted from outside the building, simply by using a T-coil-equipped hearing aid. If security is important, that is a consideration. Spill also means that if more than one loop is installed in a building measures are required to prevent interference between them.

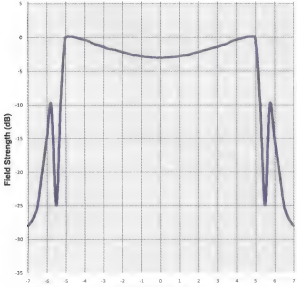


Fig.4: field strength over loop area for a 10m square loop at a height of 1m above loop.

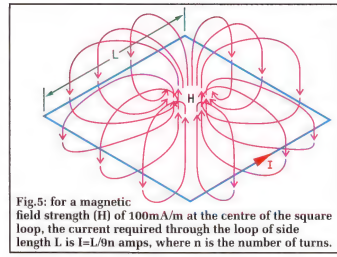


Fig.5: for a magnetic field strength (H) of 100mA/m at the centre of the square loop, the current required through the loop of side length L is I=L/9n amps, where n is the number of turns.

More than one loop will be required where a very large area needs to be covered. If each loop broadcasts the same signal, then using out-of-phase adjacent loops can minimise signal loss at the loop junction.

Where the signal in each loop is different (eg, in a multi-cinema theatre) the loop design must prevent any signal spill into adjacent loops. Special loop designs enable spill to be minimised. For more information on spill control, see Ampetronic's website: www.ampetronic.com

Coverage area

In many cases it is only necessary to provide loop coverage for part of a room or hall rather than attempt to provide for the full area.

For example, where a hall has seating for say 500 people, you may only need to provide hearing loop coverage for 50 seats or perhaps even less. This would mean that a map would be required to show potential users the designated listening area and/or any booking system would need to provide priority for hearing impaired within that area.

A smaller loop also means that a lower-powered amplifier can be used.

Amplifiers for Hearing Loops

As noted, an audio amplifier is required to "drive" the loop. You have three choices: using a commercial hearing loop amplifier, using a standard commercially-made amplifier . . . or you build your own!

Most commercial amplifiers specifically made for hearing loop use are "current" amplifiers, whereas "ordinary" amplifiers, including ones you would build yourself, are "voltage" amplifiers.

Current amplifiers have the advantage that the loop current does not vary with frequency, which would normally occur due to the inductance of the loop. However, standard voltage amplifiers can be used as well although it is true that they provide reduced current to the loop as the frequency rises. This is easily fixed, in most cases, with some judicious treble boost.

And with our signal pre-conditioner for power amplifiers to be described in a future issue, using a voltage amplifier becomes very practical.

Minimum load for a voltage amplifier

One requirement when using a voltage amplifier is that the

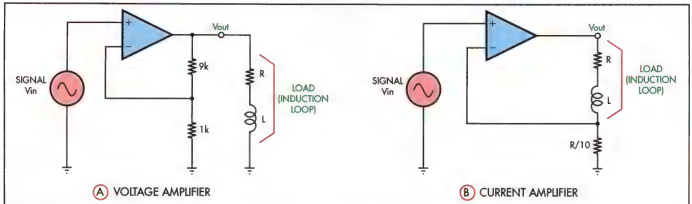


Fig.6 (left): a voltage amplifier driving a hearing aid loop load will produce less current in the loop with rising load impedance. Fig.7 (right) : a current amplifier driving a hearing aid loop load will maintain current in the loop with rising loop impedance. More on this subject next month.

loop must be designed to suit its minimum load, typically 4Ω.

Hence, the design is based on the size of the loop and wire gauge required to provide a 4Ω DC resistance. Once you have decided on the hearing loop dimensions, you add up the length of wire sides (almost invariably the "loops" are rectangular or square) required to make up the loop (don't forget the wire between the loop and the amplifier). Then the gauge of wire to provide a 4Ω load is selected from Table 1.

But that is not the full story because the wire must be able to carry the current needed to produce the required magnetic field strength of 100mA/m (millamps/metre). This 100mA/m field strength is the standard level long term average signal level. With normal program material, peak signals can be 12dB higher or up to 400mA/m.

To allow for this we have set a large factor of safety for the wire current rating by restricting average wire current to 5A/square mm when the wire could easily accept 8-10A continuously.

Calculation of the current requirements to produce the 100mA/m field strength (H) at the centre of a square loop and along the same plane as the loop uses the equation:

Current (A) = L(m)/9n, where L(m) is the length of the side in metres and n is the number of turns.

For the purposes of loop design, a rectangular loop can use the same equation with L as the smaller of the rectangle sides.

As an example, when using the equation for a single-turn 9m square loop, a current of 1A is required to produce the 100mA/m field. For a 2-turn loop the current requirement to produce that same field is halved, to 0.5A.

How much amplifier power?

The amplifier power needed must allow for the signal to be +12dB over the base signal level, without overload (ie, clipping). So the required amplifier power requirement will be (current required for 400mA/m field strength) squared multiplied by the 4Ω load.

As an example, if the current required is 1A, the power will only be 4W. If it is 4A, the power required will be 64W.

Listener's height

Another factor to consider is that the maximum field strength lies in the same plane as the loop and will be lower at a distance above (or below) the plane of the loop. So a design for monitoring signal in the same plane of the

Table 1: Loop wire and current calculator

Wire size	Wire cross section area (mm^2)	Wire current capacity (based on 5A/mm^2) (A)	Ohms per metre (Ω/m) (based on 0.017241Ω mm^2/m at 20°C)	Wire length required for 4Ω (For figure-8 wire use half this length)	Maximum square loop size (two turns)	Current for 100mA/m for max. loop size (A)	Current required for 1.7m above or below loop (A)
1 x 0.25mm	0.049	0.245	0.351	5.7m	0.7m square	0.078	-
1 x 0.315mm	0.07793	0.389	0.2212	18m	2.25m square	0.25	1.50
1 x 0.5mm	0.1963	0.982	0.0878	45m	5.63m square	0.63	1.01
14 x 0.14mm	0.21555	1.077	0.080	50m	6.25m square	0.70	1.05
14 x 0.18mm	0.3626	1.81	0.0484	84m	10.5m square	1.17	1.40
14 x 0.20mm	0.43982	2.20	0.039	104m	13m square	1.44	1.58
19 x 0.18mm	0.48349	2.42	0.03566	112m	14m square	1.56	1.64
20 x 0.18mm	0.50894	2.54	0.03388	118m	14.75m square	1.64	1.71
24 x 0.20mm	0.75398	3.77	0.02287	176m	22m square	2.44	2.45
41 x 0.20mm	1.28805	6.44	0.013387	298m	37.5m square	4.17	4.18

When you've decided on a loop dimension, use this to read off the nearest wire size and length required to make a 4Ω load.

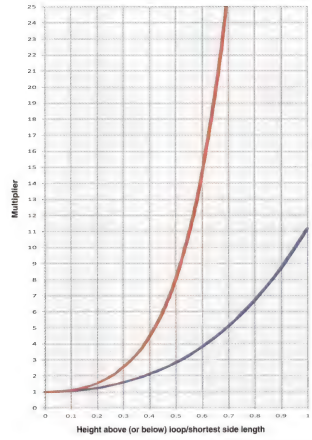


Fig.8: extra current and power are required for height offsets above or below the loop plane to maintain field strength.

loop will not deliver that field strength at a higher level above the plane.

For most hearing loop installations the loop is either placed just below the floor, at floor level or in the ceiling. Typically, this means that the listener's hearing aid is about 1.7m above or below the plane of the loop.

Fig.8 shows a graph of the extra current and power required for height offsets above or below the loop plane. To use the graph, divide the distance that the hearing aid will be above or below the loop plane by the shorter side length of the loop. So if the loop has a 5m shorter side and the height is 2m above the loop, the division gives us 0.4. Comparing 0.4 on the graph gives us a multiplier of about 2.1 times more current that must be applied to the loop to maintain the field strength at 2m above (or below) the loop plane.

While the current needs to be 2.1 times greater, power requirements must be 4.4 times greater. This is where larger loops are better in this respect because the height above or below the loop plane is relatively small compared to the loop side dimension.

This fact is important to consider because users of the induction loop are seldom all the same height, nor do they always remain at the same height. They might stand some of the time and sit for other times or they could be in a wheel chair. Ideally the loop should be sized so that the field strength does not vary by more than 3dB between the lowest and highest listening heights.

The graph of Fig.8 can also be used to determine the variation in field strength with changes in listening height. That is because the current is directly proportional to field strength. If the listening height is changed so that more current is required in the loop to maintain field strength, then that means that the field strength will be lower at that height if the current is not increased to compensate.

Height comparison

So let's compare the variation in field strength between when a person is standing and when seated. We choose 1.7m as the expected highest listening point above the loop plane noting that hearing aids are at ear level rather than the height of the person. We choose 0.5m as the lowest expected listening height above the loop plane. For a 6.8m loop, a 1.7m height gives a 0.25 height to loop dimension ratio and the current multiplier is about 1.4. For the 0.5m height, the ratio against the loop dimension is very close to 0.1 and the multiplier is very close to 1.

A 1.4 variation in field strength corresponds to a 3dB change. Taking the log of 1.4 and multiplying by 20 calculates this. So for the 6.8m square loop; if the loop current is set so the signal strength is correct at the 1.7m height, then the field strength will increase by 3dB at the 0.5m height due to the closer proximity to the loop. If the loop field strength is set for correct level at 0.5m, then the strength will drop by 3dB at 1.7m in height.

The calculation shows that a 6.8m square loop is the smallest sized loop that will provide only a 3dB change in field strength level between the two expected minimum and maximum heights above the loop.

Smaller loops will have a wider variation while larger loops will have less variation. If you are after minimal variation in field strength with height changes, use a larger loop. A 10m loop, for example, will show less than 3dB variation with a 2m change in listening height.

Note that the extra power requirements for the amplifier are very high when the listening height above or below the loop is significant compared to loop size. For example if you are using a 2m loop and are 1m above the loop, the 0.5 height to loop size ratio shows a loop current require-

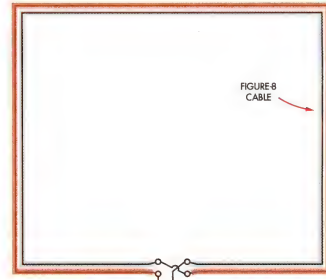


Fig.9: this shows how to form a 2-turn loop using figure-8 wire.

ment of 2.8 times higher compared to directly along the loop plane. Power requirements are eight times more. This also means that a 2m square loop is impractical because the listener must remain fixed at the one height otherwise the signal level will vary too much.

When you have decided on a loop dimension, use Table.1 to read off the nearest wire size and length requirement to make a 4Ω load. You might require extra wire if the amplifier is not located close to the loop. Note that the table only shows figure-8 wire length. Figure-8 wire comprises two insulated and parallel running wires and when connected to make a single length of wire will form a 2-turn loop (see Fig.9).

We show only figure-8 wire in the table because interestingly, a 2-turn loop is the only practical option for an induction loop that is driven using a voltage amplifier. It works out that a 2-turn loop that provides a 4Ω load will have the correct current rating to prevent overheating the loop wire.

This applies even with the extra current requirement for loop monitoring at 1.7m above or below the loop. Using a single turn loop requires twice the current for the 100mA/m field strength and is likely to overheat the loop wire, making it impractical.

Using more than two turns is not recommended because of loop inductance which increases by the square of the number of turns. So while two turns produces four times the inductance of a single turn loop, a four turn loop will have 16 times the inductance.

Higher inductance means that the amplifier (whether a current or voltage type) needs to be able to provide much more voltage drive at higher frequencies. More details about this inductance effect are provided later.

The table has values of wire resistance calculated based on copper resistance at 0.017241Ω mm^2/m at 20°C. The cross sectional area is the radius of the wire squared times pi(π). For wire with more than one strand, the area for one strand is multiplied by the number of strands. The ohms/metre value was obtained by dividing the total cross sectional area into the 0.017241Ω mm^2/m.

Power requirements for a given loop size is calculated using the required current to produce the 100mA/m field and multiplying this by four to get the current for the 400mA peak. For a 2-turn loop, divide this value by two. Overall, this simplifies to multiplying the current for the 100mA/m field by two. The value is then squared and multiplied by the resistance (4Ω) to obtain the power requirement.

Chances are that the loop you are using will not be exactly one of the loop sizes listed in the table. For an in-between value loop size, use the next lowest listed loop size wire gauge. This will mean that the resistance will be higher than 4Ω due to the extra length for the larger loop. Amplifier power requirements may need to be higher if the rated power of the amplifier you are using is close to the amount of power required.

To simplify calculations, Fig.10 shows amplifier power requirements for a 2-turn 4Ω loop of various sizes. One graph shows power required for directly at the loop plane and the second for 1.7m above (or below) the plane. The power requirements take into consideration the 400mA/m field strength produced during signal peaks. As mentioned if the loop is more than 4Ω, power requirements will need to be increased by the same ratio. So an 8Ω loop will require

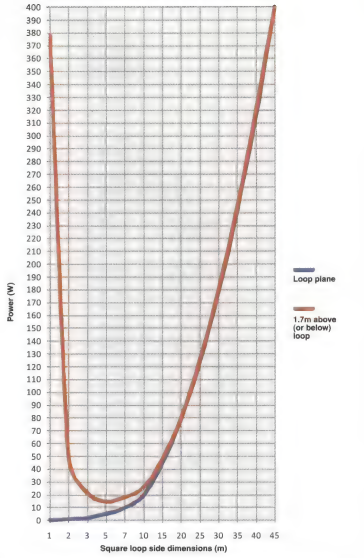


Fig.10: amplifier power requirements when driving a 2-turn 4Ω loop of various sizes. Power is shown for directly along the loop plane and 1.7m above (or below) the plane.

double the power. There is no problem using an amplifier that has more power than is required.

For a loop of 15m and larger, the power requirements for along the plane and 1.7m are almost the same. This means that the field strength in the loop effectively does not vary over a 1.7m range.

As a consequence any change in listening height above the plane of the loop will not be subject to variation in signal level. In practice 10m square loops also do not appear to have any noticeable signal level change with normal variations in height.

What voltage amplifiers are suitable?

As mentioned, a voltage amplifier for the loop designs described here needs to be able to drive a 4Ω load and it must be unconditionally stable. This is important because we do not want the amplifier oscillating at a very high frequency and radiating radio frequencies. In addition, the amplifier would produce lots of distortion if it is prone to oscillation.

While many commercially made amplifiers could be used, Table 2 shows some of the more recent and suitable amplifiers that Silicon Chip has published. The table

indicates the recommended sized loop that could be used with each.

The amplifier power requirement for the loop size takes into account the fact that the loop will be about 1.7m away from the listening position. See www.jaycar.com.au and www.altronics.com.au for kits.

Loop Inductance

We mentioned that loop inductance was a concern because it reduces the amount of current that is applied to the loop as frequency increases. Hence, treble boost is needed.

Australian Standard AS60118.4-2007 recommends that the frequency response of the magnetic field be 100Hz to 5kHz within ±3dB. Naturally, the response can cover a wider range of frequencies. In practice though, having rolloff above 5kHz is ideal because it removes the need for excessive treble boost.

We plotted loop inductance versus loop size and this can be seen in the graph of Fig.12. Inductance of a square, rectangular or circular loop can be calculated using an inductance calculator.

We used the calculator at www.technick.net/public/code/cp_dpage.php?aiocp_dp=util_inductance_calculator

For the purpose of this exercise, inductance calculation was based on 1mm diameter wire (0.5mm radius). The μ value for air is 1. Inductance is shown for both a single turn loop and using figure-8 wire that forms two turns. Note how the inductance for two turns is four times that of one turn. The inductance values are based on a square loop shape. Rectangular loop inductance can be calculated using the rectangular shape option in the above mentioned inductance calculator.

Typically, a rectangular loop will have the same inductance as a square loop that has the same wire length. For example a 10m square loop has the same inductance as a 15 x 5m rectangular loop.

From the inductance we can calculate the 3dB down rolloff for a 4Ω loop. How this is calculated is described in the section entitled 'Inductance of the loop'. A simplified calculation for 4Ω loops is that the -3dB frequency = 0.6366/inductance in Henries. Multiply the -3dB frequency by two for 8Ω loops.

The graph in Fig.13 shows the –3dB rolloff frequency against loop side length. The graph reveals that for a 2-turn loop, the frequency response is no more than 3dB down at 5kHz for square loops up to almost 5m. Larger loops will require treble boost to compensate for the rolloff.

Actual rolloff against frequency for various sized loops is shown in the Fig.14 graph. For the 5m square loop, rolloff is just over 3dB down at 5kHz, but for a 20m square loop rolloff is –14dB down.

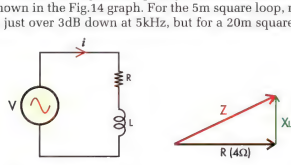


Fig.11: the total impedance of a series-connected resistor and inductor is calculated using a phasor diagram. Impedance of the resistor is R and reactance of the inductor is XL. Total impedance is Z.

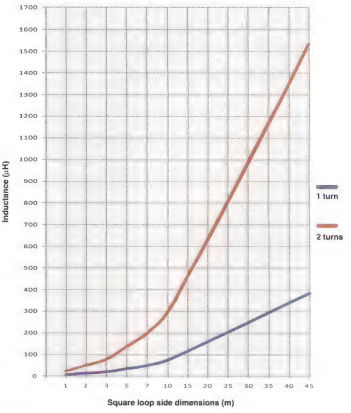


Fig.12: the plot of loop inductance versus loop size. The graph shows inductance for both 1-turn and 2-turn loops. Note how inductance is four times greater in the 2-turn loop. Typically, a rectangular loop will have the same inductance as a square loop that has the same wire length.

The Hearing Loop amplifier signal pre-conditioner that we will describe in a later issue has treble boost compensation to correct for these rolloffs.

Note that adding treble boost to an amplifier's signal input might appear to mean that extra power will be required from the amplifier.

However, extra amplifier power is not normally required because the power requirement for reproducing naturally occurring sounds becomes less at higher frequencies. Typically, natural sounds have the same energy per octave. And so while there are four octaves between 100Hz and 1600Hz there are less than two octaves between 1600Hz and 5kHz. Treble boost is only applied from about 1600Hz through to 6kHz.

However for large loops (15m square and over), a fair degree of treble boost is necessary. In these cases it may be best to use a slightly higher powered amplifier than one selected from the design graph and tables, especially if the power available from the amplifier is only just sufficient for the size of the loop. It is not practical to compensate for treble loss for loops larger than 20m square.

Impedance of the loop

A hearing loop generally comprises a wire length in the shape of a rectangle or square. The impedance of the loop comprises the resistance of the wire plus the reactance due to the inductance of the loop. These two components are effectively in series. The loop resistance will remain

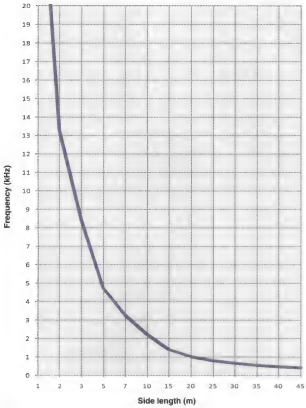


Fig.13: this shows the –3dB rolloff frequency with various loop side lengths (4Ω, two turns). Frequency response varies by no more than 3dB up to 5kHz for loops no larger than 5m square. Larger loops will require treble boost to compensate for the rolloff before 5kHz.

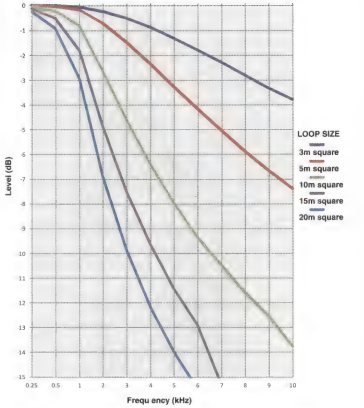


Fig.14: frequency response for various sized loops (4Ω, two turns). For a 5m square loop, rolloff is just over 3dB down at 5kHz but for a 20m square loop rolloff is –14dB down. Typically, a rectangular loop will have the same response and –3dB rolloff as a square loop with the same wire length.

reasonably constant although it will vary with temperature. The main variation in the loop will be due to the reactance that rises with frequency.

A pure resistance without inductance has a current that is in phase with the voltage. For a pure inductor, which has no resistance, the current lags the voltage by 90°. Its reactance is 2 x π x the frequency x the inductance (L). To find the total impedance effect of both the resistance and the reactance of the inductor we need to consider the two quantities as shown in the phasor diagram of Fig.11.

Resistance is shown as R and the reactance (X_L) is 90° difference in phase. To add the two values we square both the R value and the X_L value, add the two squared values and then take the square root. This gives the value of the (Z) impedance. Mathematically, this is just using Pythagoras' theorem to calculate the length of the hypotenuse in a right-angled triangle.

Assuming the resistance R is 4Ω, at low frequencies the impedance of the inductor is low and so the overall impedance is close to 4Ω. As frequency rises, the impedance of the inductor rises and begins to have a greater effect on the overall impedance of the loop.

Table 2: Silicon Chip Amplifier Data

Power into 4Ω	Loop size	Amplifier Name	Silicon Chip publication date	Kit supplier No.
20W	3-8m square	Compact High Performance 12V Stereo Amplifier	May 2010	Jaycar KC5495, Altronics K5136
30W	2.5-11m square	Schoolies Amplifier	December 2004	Altronics K5116
55W	2-16m square	50W Audio Amplifier Module	March 1994	Jaycar KC5150, Altronics K5114
70W	2-18m square	SC480	January 2003	Altronics K5120
200W	1.5-33m square	Ultra-LD Mk2	August 2008	Jaycar KC5470, Altronics K5151
350W	Up to 42m square	Studio 350 Power Amplifier	January 2004	Jaycar KC5372

This shows some of the more recent and suitable loop driving amplifiers published in Silicon Chip, ranging from 20W through to 350W. The table also shows the recommended size of loop that could be used with each.

The rising impedance has an effect on the current flow within the loop. So if an amplifier is fed with a constant voltage level, the current will reduce as frequency rises as the impedance increases. The loop current is the voltage divided by the impedance.

At low frequencies, the reactance X_L is close to zero and so the 4Ω resistance mainly sets loop current. As the frequency rises, the reactance increases, the total impedance rises and so current drops. The –3dB down frequency is when the resistance R is equal to the reactance X_L. Then the current is 0.7071 of the DC current.

As an example (and using simple numbers) lets say R is 1Ω and voltage is 1VAC. Current I at a low frequency is 1A. When the AC frequency is higher the reactance of the inductor will be 1Ω at a specific frequency depending on the inductance. The impedance Z becomes the square root of 2 or 1.414Ω. So the current is 1/1.414 or 0.7071 in value. This reduction to 0.7071A compared to the original 1A is the –3dB level.

A hearing loop does not use radio!

A common misconception with hearing loops is that they operate using radio waves. In other words, it is assumed that the loop acts as a radio antenna and the hearing aid includes a wireless receiver for reception. This is not true.

The magnetic field from the loop is simply modulated at the audio signal frequency at up to around 5kHz.

While the magnetic field produced by the loop is a part of the electromagnetic spectrum its properties are unlike radio waves: for example, the wavelength at 3kHz is so long at around 100km compared to radio waves that start at around 300m.

In the same way, the electromagnetic fields produced by 50Hz power lines are not considered to be radio waves.

Other examples of waves that are also part of the electromagnetic field spectrum include Infrared radiation (heat), visible light, ultra-violet light (UV) and X-rays. These too are not considered radio.

Health effects using a hearing loop?

While it is certain that some electromagnetic fields can cause detrimental health effects (eg, UV and X rays), it is unclear whether the low frequency and low level magnetic field from a hearing aid will have any detrimental effect. Most research concerning the effects on cells with electromagnetic radiation is concentrated on 50Hz power transmission along with the higher frequencies such as microwaves, X rays, ultra-violet radiation etc.

Mobile phones come under the microwave category and operate at around 3GHz. The microwave energy from a mobile phone is vastly higher than that from a hearing loop and its frequency is at least 1 million times greater and with much higher energy.

There is no correlation between the effects of microwave energy causing cell damage in the body and any effects caused by hearing loops.

If we consider the 50Hz power line frequency as being the closest studied radiation compared to the hearing loop, the recommended maximum continuous exposure to magnetic field is 0.1mT (milliTesla). This data was obtained from the Australian Radiation Protection and Nuclear Safety Agency. (www.arpansa.gov.au/radiationprotection/facsheets/is_emf.cfm).

The recommended magnetic field strength in audio-frequency induction loops for hearing aid purposes is 100mA/m at 1kHz rising to 400mA/m during peaks, which equates to 0.126μT and 0.5μT respectively – more than 1000 times less than the 0.1mT level.

Magnetic field strength

For the hearing loop specifications, magnetic field strength is expressed using the units of A/m or amperes per meter. The letter H is used to label this field. The field represents the total amount of field strength provided by the loop.

Another way of expressing a magnetic field is with the letter B, which is the magnetic field density and describes how the field is concentrated due to the medium within the field. Its units are in Tesla (T). The field medium can be free space (usually air) or it can be other material such as iron or ferrite. These latter mediums distort the magnetic field with higher concentrations found within the iron or ferrite.

Where a hearing loop is installed and there is significant steel in the field, then available field strength in the free space (air) will be reduced because the field will be concentrated through the steel. The hearing loop needs to be driven with more power to counteract the loss within the steel.

The B field strength values and the H magnetic field density values are easily converted from one to the other using the equation $B=\mu H$. B is the magnetic flux density (T) and μ is the permeability of the magnetic field medium. This is $4 \times \pi \times 10^{-7}$ for air and free space.

For a hearing loop, the 100mA/m field strength produces a field density of 0.126μT. The 400mA/m level is 0.5μT.

By the way, if you prefer to use Gauss (G) units instead of Tesla, the conversion is 0.1μT=1mG. So 0.126μT is 1.26mG.

An under-floor hearing loop installation. Unfortunately, under-floor access is rarely this good. Special considerations also apply if the floor is steel-reinforced concrete; indeed under-floor loops may not be possible.

Next month

We'll continue our look at Hearing Loops, examining at some of the commercial equipment available. SC

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Build it & kee
at ba

Marine growth on the hull is the bane of all boat owners. Left unchecked, marine growth slows the boat down considerably and if it's a power boat, leads to large increases in fuel consumption. If it's a yacht, marine growth will also slow it down and make it less manoeuvrable, to the point where it becomes very sluggish. The cure is to haul the boat out of the water every year and water-blast and scrape away all the growth and then coat the hull in toxic anti-fouling paint.

Pt.1: By LEO SIMPSON & JOHN CLARKE

EVERYONE KNOWS that owning and maintaining a boat is expensive; the bigger the boat, the more expensive it is.

Many readers will be familiar with trailer sail-boats and power boats. These are relatively cheap to run and since they are not left in the water, they should never have problems with marine growth. However, once you have a boat on a swing mooring or tied up to a berth in salt water, marine growth is endemic and the warmer the water, the more severe the problem.

The vast majority of larger boats in Australia and New Zealand are moored in warm, salty waters and so marine growth is a big problem. In years past, the solution was to coat the hull in an arsenic-based anti-fouling compound but these were highly toxic to all marine life and have now been banned. This means that the anti-fouling compounds used now, while still toxic to marine growth, are far less effective.

The problem is even more severe for boats that are moored in canal developments. There, because the water is much warmer and there is little water movement, marine growth can be so rapid that anti-fouling needs to done as often as every six months.

If a boat is not being used, marine growth can still rapidly take hold and there can be significant growth after only a few months. This is because anti-fouling coatings are "ablative" which means that they depend for their operation on the boat moving through the water to literally wear off the surface and thereby expose fresh (and toxic) anti-fouling compound.

So anti-fouling needs to be done at least once a year and in some cases, more frequently if the boat is seldom used or moored in a canal. If you do this work on your own boat, it is tedious, dirty and expensive (even hauling the boat out of water is expensive). If you pay someone else to do it, it is much more expensive. All boat owners would love to avoid this cost.

Now there is ultrasonic anti-fouling for boats. This electronic method means the end of chemical anti-fouling and a big reduction in cost for boat

the barnacles electronically

The driver circuit is housed in an IP65 ABS box with a clear lid. It produces the high-voltage pulsed waveform that's used to drive the ultrasonic transducer.

owners. It involves installing a high power piezoelectric transducer inside the boat's hull and then ultrasonic energy keeps marine growth at bay.

How it works

The way that this works is that the ultrasonic vibration of the hull disrupts the cell structure of algae and this stops algal growth adhering to the hull. And because there is no algal food source on the hull, larger marine organisms have no reason to attach themselves to the hull – no food, no lodgers.

The principles of ultrasonic anti-fouling have been known for a long time. The effect was discovered 80 years ago by French scientist Paul Langevin who was developing sonar for submarines. By accident, he found that ultrasonic energy killed algae. He was working with high power transducers and it was assumed that cavitation was causing algal death. In recent times though, it has been found that high ultrasonic power and cavitation is not required to kill algae.

Instead, it has been found that ultrasonic frequencies can cause resonance effects within algal cell structures and relatively low powers are still enough to cause cell death. So if the boat's hull can be vibrated over a range of ultrasonic frequencies, algae will not be able to attach to it and other marine growth will similarly be discouraged.

Commercial ultrasonic anti-fouling systems have been available for the last few years but they are very expensive, costing thousands of dollars to install. There is still a cost benefit though and these systems are gradually becoming more popular as news of their effectiveness grows. However, we should state at the outset that the manufacturers do not make blanket guarantees that ultrasonic anti-fouling systems work in every situation. We can understand that.

It's this lack of a blanket guarantee that's probably holding back market acceptance. Most boat owners will be very cautious about investing several thousand dollars in a system that may not work in their case. That is where the SILICON CHIP design will be a game-changer. It will cost a fraction of the price of equivalent commercial sys-

WARNING!

This circuit produces an output voltage of up to 800V peak-peak to drive the ultrasonic transducer and is capable of delivering a severe electric shock. DO NOT touch the output terminals at CON2, the PC tracks leading to CON2 or the transducer terminals when power is applied.

To ensure safety, the PC board must be housed in the recommended plastic case, while the transducer must be correctly housed and fully encapsulated in resin as described in Pt.2.

Specifications

Overall output frequency range: from 19.08kHz to 41.66kHz in 14 bands; frequency overlapping included between each band

Frequency sweep in each band: 12 frequencies ranging from approximately 80Hz steps at 20kHz to 344Hz steps at 40kHz

Signal burst period: 600ms at 20kHz, 300ms at 40kHz (1000 cycles/ burst)

Pause between each band: 500ms

Dead-time for push-pull driver: 5µs

Output drive: 250VAC (up to 800V peak-peak)

Low voltage threshold: 11.5V (switch-on voltage = 12V)

Supply Voltage: 11.5 - 16V maximum

Current drain: 220mA average at 12V driving a 3.6nF load

Peak current at transducer resonance: 3A

Quiescent current below 11.5V: 6.7mA

tems yet should have the same effects.

Our system works along the same lines as commercial systems. It uses a high-power piezoelectric transducer which is attached inside the hull. It is driven with bursts of ultrasonic signal ranging between about 20kHz and 40kHz. The reason for using a range of frequencies is two-fold. First, we want to drive the transducer over a range of frequencies so that various resonance modes of the hull are excited. Second, this range of frequencies is required to kill the various types of algae.

While a high-power transducer is used and we do drive it with very high voltages, the actual power used is not very great so that the typical current consumption from a 12V battery is around 220mA (3A peak).

The large ultrasonic transducer is driven with high-frequency signal bursts ranging from 19.08kHz up to 41.66kHz.

Since the ultrasonic anti-fouling system should ideally run continuously, the 12V battery will need to be permanently on charge. This is no problem for boats in berths which have shore power (ie, 230VAC mains). For boats on swing moorings, a solar panel and battery charge controller will be required. We will describe a suitable system in a future issue.

So let's have a look at the SILICON CHIP ultrasonic anti-fouling driver. This is housed in a compact sealed plastic IP65 case with a transparent lid. There are two cable glands on one side of the case for the power supply cable and for the cable to the piezoelectric transducer which is itself encapsulated in a high-pressure plumbing fitting.

The driver module is based on a PIC12F675-I/P microcontroller, two power Mosfets and a step-up transformer. It can be powered from a 12V battery or a 12V 3A (or greater) power supply, if shore power is available.

Ultrasonic bursts

In more detail, the piezoelectric transducer is driven with bursts of high-frequency signal ranging from 19.08kHz through to 41.66kHz. This is done over 14 bands with each band sweeping over a small frequency range.

The first band is from 19.08kHz to 20.0kHz and comprises 12 frequencies with approximate 83Hz steps between each frequency. The other bands also have 12 frequencies but with larger frequency steps. For the middle band at 24.75kHz to 26.31kHz, the steps are about 141Hz. For the top band between 37.87kHz and 41.66kHz, the steps are 344Hz.

Each band overlaps the following band by a few hundred Hertz. This overlap ensures that the whole range of frequencies is covered from 19.08kHz to 41.66kHz.

Each burst of signal comprises two separate frequency bands each of 500 cycles. The burst period for the total 1000 cycles depends on the actual frequency bands that are in the burst – from 300-600ms. There is a 500ms no-signal gap between each burst.

The two frequency bands for each burst are varied in a pseudo-random way so that the entire range of frequencies is covered within 16s. This sequence is repeated after about 64s.

Note that there is a concentration of signal about the resonant frequency of the transducer between 35.21kHz and 41.66kHz.

Circuit description

Now let's have a look at the circuit of Fig.1. The PIC microcontroller IC2 drives step-up transformer T1 via two Mosfets, Q1 & Q2. In addition, the microcontroller provides a low-voltage shutdown to prevent the battery from discharging below 11.5V.

The microcontroller runs at 20MHz (as set by crystal X1) and this allows it to provide the small ultrasonic frequency shifts listed above.

Pins 6 & 7 of IC2 drive Mosfets Q1 & Q2 which in turn drive transformer T1. Since these outputs only swing from 0V to +5V we have specified logic-level Mosfets, type RFP30N06LE. Their "on"resistance (between the drain and source) is a mere 75mΩ for a gate voltage of 3V and it drops even lower to around 23mΩ at a gate voltage of 4.5V. Their current rating is 30A continuous.

Mosfets Q1 and Q2 are driven alternately and in turn drive separate halves of the transformer primary winding. The centre tap of the primary is connected to the +12V supply rail.

When Q1 is switched on, current flows through its section of the primary winding for less than 50µs, depending on the frequency, after which Q1 is switched off. After 5µs, Q2 is then switched on for less than 50µs. Then, when Q2 switches off, there is another gap of about 5µs before Q1 is switched on again and so on.

The 5µs period during which both Mosfets are off is "dead time" and it allows one Mosfet to fully switch off

before the other is switched on.

The alternate switching of the Mosfets generates an AC square-wave in the primary and this is stepped up in the secondary winding to provide a voltage of about 250VAC, depending on the particular frequency being switched and the resonance of the piezoelectric transducer load.

Mosfets Q1 & Q2 include over-voltage protection to clamp drain voltages which exceed 60V. This clamping is required since a high-voltage transient is generated each time the Mosfets switch off.

Protection for the gates of the Mosfets is provided using 5.1V zener diodes ZD1 & ZD2. This might seem unnecessary since the Mosfets are only driven from a 5V signal but the high transient voltages at the drains can be coupled into the gate via capacitance. These 5.1V zener diodes also help prevent damage to the GP0 and GP1 outputs of IC2.

Further protection is provided for the GP0 and GP1 outputs of IC2 using Schottky diodes D1 & D2. These clamp the voltages at these pins to about +5.3V. They are in parallel with the internal protection diodes at GP0 and GP1.

Battery voltage monitoring

The incoming 12V supply is monitored via a voltage divider consisting of 10kΩ and 20kΩ resistors and the resulting voltage is filtered and monitored by IC2 at pin 5, the AN2 input. IC2 converts this voltage into a digital value and this is compared against a reference value in the software. With an 11.5V supply, the voltage at pin 5 is 3.83V and below this threshold voltage IC2 cuts off the drive for Mosfets Q1 & Q2. This prevents over-discharge of the boat battery.

Once IC2 is in low-voltage shutdown mode, the supply voltage needs to rise to 12V before the Mosfet drive is resumed. This 0.5V hysteresis prevents the shutdown switching being on and off repetitively at the 11.5V threshold.

The 5V supply rail for IC2 is provided by a TL499A regulator, IC1. This is a low quiescent current regulator that can run in linear stepdown or switch-mode step-up modes. We are using it in linear stepdown mode. Its output voltage is trimmed to exactly 5V using trimpot VR1. This is done to set the low-voltage shutdown threshold.

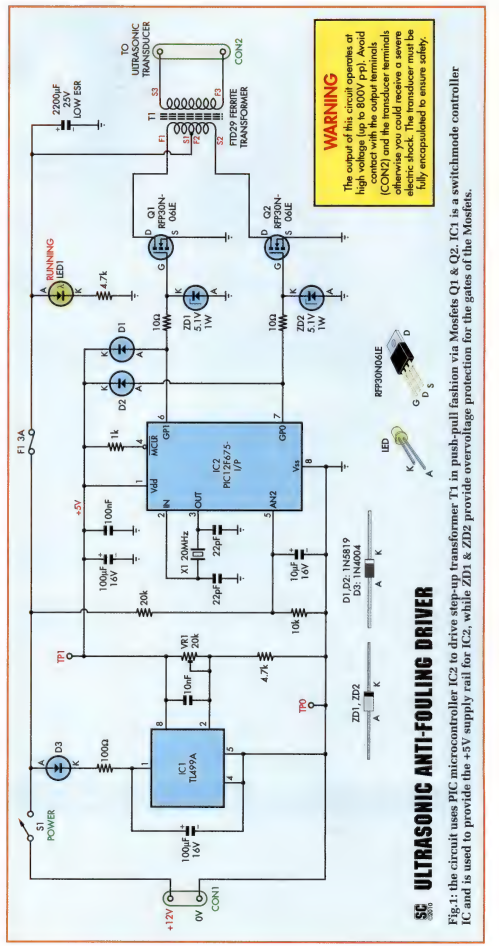


Fig.1: the circuit uses PIC microcontroller IC2 to drive step-up transformer T1 in push-pull fashion via Mosfets Q1 & Q2. IC1 is a switchmode controller IC and is used to provide the +5V supply rail for IC2, while ZD1 & ZD2 provide overvoltage protection for the gates of the Mosfets.

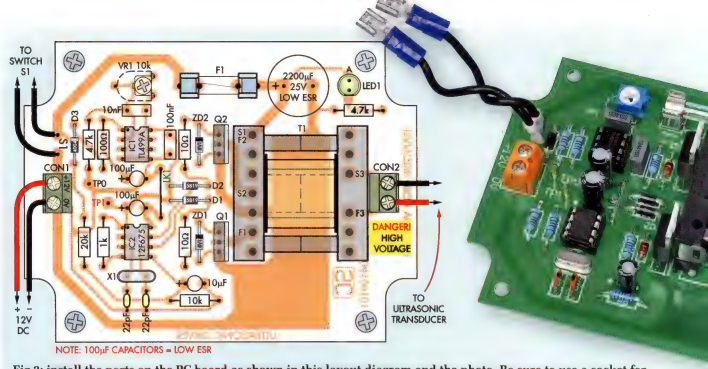


Fig.2: install the parts on the PC board as shown in this layout diagram and the photo. Be sure to use a socket for the PIC microcontroller (IC2) but do not install this IC until after the setting-up adjustment has been completed.

The circuit includes reverse polarity protection. IC1 is protected by diode D3 and in turn protects IC2. The Mosfets are protected via their substrate diodes and fuse F1. If the supply is reversed, the diodes conduct via the transformer's primary until the fuse blows. Before that happens, the supply is effectively clamped at around -1V and thereby protects the 2200µF electrolytic capacitor from excessive reverse voltage.

The fuse prevents the PC board tracks from fusing should the transformer be wound incorrectly or if one of the Mosfets fails as a short circuit.

Assembly details

The Ultrasonic Driver is constructed on a PC board coded 04109101 and measuring 104 x 78mm. It has corner cutouts to allow it to be mounted in an IP65 ABS box with a clear lid, measuring 115 x 90 x 55mm.

Begin by checking the PC board for breaks in the tracks or shorts between them. Check also that the hole sizes are correct for each component to fit neatly. The screw terminal holes and transformer pin holes are 1.25mm, while larger holes again are used for the fuse clips.

Assembly can begin by installing the resistors and PC stakes. Table 1 shows the resistor colour codes but you should also check each resistor using a DMM. The PC stakes are installed at TP0 & TP1 and at the external wiring points for switch S1.

Follow these with the diodes which must be orientated as shown. Note that there are three different diode types: 1N5819s (Schottky) for D1 and D2, 1N4004 for D3 and 5.1V zener diodes for ZD1 & ZD2.

IC2 is mounted on a DIP8 socket so install this socket now, taking care to orientate it correctly. Leave IC2 out for the time being though. IC1 can also be socket mounted or it can be directly soldered into place. Again ensure the orientation is correct.

Crystal X1 and the two 2-way screw terminal blocks can be installed next. Make sure the screw terminals are oriented with the opening toward the outside edge of the PC board. Q1 and Q2 can then be mounted so that their tabs are 25mm above the PC board. Their metal tabs face transformer T1.

LED1 is mounted with its top 30mm above the PC board (its anode has the longer lead). The capacitors can then go in, followed by trimpot VR1. Make sure that the electrolytic capacitors are oriented correctly.

Transformer details

Fig.3 shows the transformer wind-

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
22pF	NA	22p	22

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	20kΩ	red black orange brown	red black black red brown
1	10kΩ	brown black orange brown	brown black black red brown
2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
1	1kΩ	brown black red brown	brown black black brown brown
1	100Ω	brown black brown brown	brown black black black brown
2	10Ω	brown black black brown	brown black black gold brown

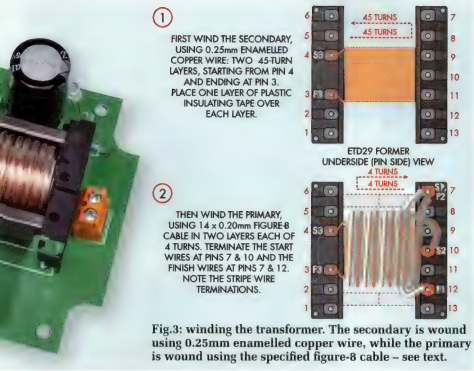


Fig.3: winding the transformer. The secondary is wound using 0.25mm enamelled copper wire, while the primary is wound using the specified figure-8 cable – see text.

ing details. The primary winding uses eight turns of figure-8 14 x 0.20mm wire, wound in two layers, to give a bifilar winding. The secondary uses 0.25mm enamelled copper wire wound in two layers of 45 turns each, with insulation tape between the two layers.

While this may seem confusing, the secondary winding is done first. To do this, first strip the enamel from one end of the 0.25mm enamelled copper wire using some fine emery paper or a hobby knife to scrape it off. Pre-tin the wire end and wrap it around pin 4 on the underside of the transformer bobbin and solder it close to the bobbin.

Now wind on 45 turns side-by-side to make the first layer. The direction of winding (whether clockwise or anticlockwise) doesn't matter. Cover this winding layer with a single layer of plastic insulation tape. Now continue winding in the same direction back across the insulation tape to complete 90 turns. Terminate the wire onto terminal 3, then cover the secondary winding in a layer of insulation tape.

The primary winding, made from the figure-8 cable, is first stripped of 10mm of insulation at one end and the two wires are soldered to the bobbin at pins 7 & 10, with the grey polarity stripe to pin 7. Now wind on four turns making sure the wire lies flat without twists, so that the striped wire stays to the left. The four turns should fully fill the bobbin and the next four turns will be on the next layer (there's no need for insulation tape between them). Terminate the striped wire end onto pin 12 and the other wire to pin 7.

Once wound, slide the cores into the former and secure with the clips. These clips push onto the core ends and clip into lugs on the side of the bobbin.

The transformer can now be installed on the PC board. Note that its primary side has seven pins and the secondary side has six pins, so it can only go in one way. That completes the PC board assembly.

The front panel label can now be downloaded from our website as a PDF file. You can print it out onto paper or clear overhead projector film. That done, mark out and drill the hole in the lid of the case for switch S1.

When mounting the switch, make sure that it is firmly seated in the clear lid. If it tends to pop out of place, you will need to use some silicone sealant to ensure it is firmly anchored (and waterproof).

The label is mounted inside the lid so it is protected. It can be attached to the lid with clear tape or clear silicone sealant. The hole for switch S1 is cut out of the panel label using a sharp hobby knife.

Two holes are required in one side of the box for the power lead cable gland and for the cable to the ultrasonic transducer. These cable gland holes are located 27mm up from the bottom of the case and are positioned

Parts List

1 PC board, code 04109101, 104 x 78mm
1 IP65 ABS box with clear lid, 115 x 90 x 55mm (Jaycar HB6246 or equivalent)
1 ETD29 transformer with 2 x 3C85 cores, a 13-pin former & 2 retaining clips (T1)
1 IP65 10A push-on/push-off switch (S1) (Jaycar SP-0758)
1 300mm length of 14 x 0.20mm figure-8 wire
1 3m length of 0.25mm enamelled copper wire
1 100mm length medium-duty hookup wire
1 3A M205 fuse
2 M205 PC fuse clips
2 2-way screw terminals with 5mm or 5.08mm pin spacing
1 DIP8 socket
2 IP65 6.5mm cable glands
1 20MHz crystal (X1)
1 20kΩ horizontal trimpot (Code 203) (VR1)
4 PC stakes
4 M3 x 6mm screws
2 6.4mm female spade lugs
1 20mm length 3mm-diameter heatshrink

Semiconductors

1 TL499A switchmode controller (IC1)
1 PIC12F675-I/P programmed with 0410910A (IC1)
2 RFP30N06LE Mosfets (Q1,Q2)
2 1N4733 5.1V 1W zener diodes (ZD1,ZD2)
2 1N5819 1A Schottky diodes (D1,D2)
1 1N4004 1A diode (D3)
1 3mm LED (LED1)

Capacitors

1 2200µF 25V low ESR electrolytic
2 100µF 16V low ESR electrolytic
1 10µF 16V electrolytic
1 100nF MKT polyester
1 10nF MKT polyester
2 22pF ceramic

Resistors (0.25W, 1%)

1 20kΩ	1 1kΩ
1 10kΩ	1 100Ω
2 4.7kΩ	2 10Ω

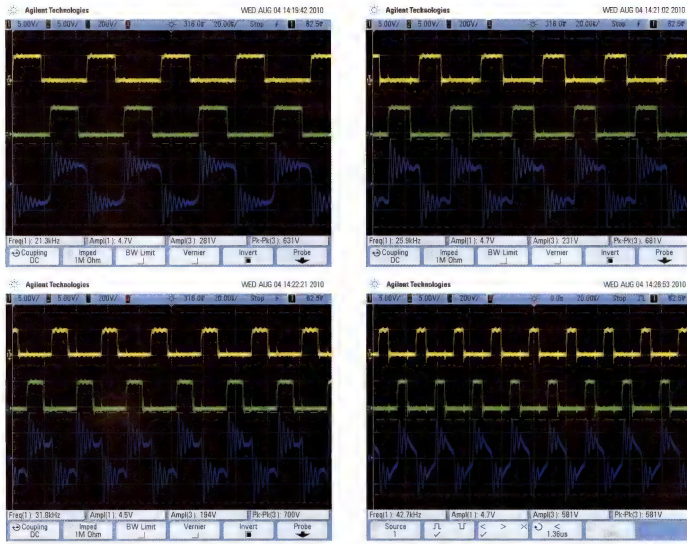


Fig.4: the yellow and the green waveforms in each of these scope grabs show the alternate gate signals for Mosfets Q1 & Q2, while the lower (blue) trace shows the resulting high-voltage waveform in the secondary of the transformer. Four scope grabs are shown here to show the range of frequencies covered and these are varied in a pseudo-random sequence.

This view shows the driver board mounted inside the case. Do not apply power to the completed unit unless the transducer (which must be fully encapsulated) is connected – see text.

as shown in the photos. They are both 12mm in diameter.

Adjustment

Before going further, remove fuse F1 and check that IC2 has NOT been fitted to its socket. This ensures that no high voltages appear at the output during adjustment. That done, secure the board in the case using four M3 x 6mm machine screws into the integral supports, then connect a DMM set to read DC volts between TP1 & TP0. Apply power and adjust VR1 for a reading of 5V.

Now disconnect the power and install IC2 and the fuse. Once this has been done, do not apply power again unless the transducer is connected and then only after the latter has been fully encapsulated – see warning panel.

Next month, we will describe how to encapsulate the piezoelectric transducer in a standard high-pressure 50mm male adaptor. We will also show you how to install the finished transducer assembly and driver module in the hull of a fibreglass cruiser. SC

PRODUCT SHOWCASE

Electrical installation & socket outlet tester

The Metrel InstalTest Combi MI-3125 multi-function installation tester from Emona Instruments provides all of the functions normally found on multi-function installation testers such as insulation resistance, continuity, RCD test, fault loop impedance, phase rotation, voltage and frequency measurement.

In addition, it offers a unique "Socket Outlet Test", which allows users to quickly and easily test the electrical safety of a socket outlet.

It eliminates the need for a trailing lead connection from the PE terminal on the socket outlet to the PE bar in the switchboard for the earth resistance test, conducts the 3 polarity tests between active, neutral and earth between the socket outlet and the switchboard and indicates a Pass/Fail test result. It tests the active-earth, neutral-earth, active-neutral connections and compares the results to the 10Ω, 5Ω and 150Ω values from the connected Resistor Box.

It also allows users to set Pass/Fail limits, offering a quick and simple way to carry out compliance testing across any electrical installation, from insulation resistance and RCD testing through to fault loop impedance.

The MI-3125 offers electrical contractors a next generation installation testing tool that will guarantee faster faultfinding and provide more accountability, when compliance testing new circuits and installations according to state electricity safety regulations and AS/NZS3000 Wiring Rules.

Contact:
Emona Instruments
PO Box 15 Camperdown NSW 1450
Tel: (02) 9519 3933 **Fax:** (02) 9550 1378
Website: www.emona.com.au

XY mode for Screenscope

Screenscope now supports XY mode function, where channel 1 is plotted against channel 2.

The drawing is done at the hardware level with dot joining to give fast real-time performance. Unlike on an analog scope the other channels can also be displayed at the same time, allowing easier setting up and triggering for best displayed waveform.

The screenshot above shows the trace doing several circuits of a rotating Lissajous figure from the comparison of two sine waves. XY mode is also useful for parametric measurements and studying dynamical systems.

Screenscope's measurement markers can also be used on the XY trace to directly read the voltage values at any point in both X and Y directions.

XY mode is available to existing users as a flash download. Visit www.screenscopetraces.com

This month's "Electronex" expo headed for a sellout – and SILICON CHIP will be there!*

ElectroneX
electronics design & assembly expo

"Electronex" – The Electronics Design and Assembly Expo – being held this month at Australian Technology Park in Sydney has been welcomed by electronics suppliers, excited about the opportunity to have their own dedicated trade event in Australia.

Electronex is organised by Australasian Exhibitions and Events (AEE) in association with The Surface Mount and Circuit Board Association (SMCBA) and will include a dedicated industry trade show and technical conference.

The expo features all the market leaders and will provide visitors with an opportunity to see all the major companies together at the one show. Many of the exhibitors will be showcasing new releases and new technology that has not been seen before and will provide trade visitors with an excellent opportunity to keep up to date with the latest products and innovations.

Electronics Engineers and decision makers throughout Australia, New Zealand and SE Asia are invited to attend and will be able to see an extensive range of products and services as well as seek advice and find solutions for their specific needs and applications. The expo will cover all aspects of electronics assembly, design, test, measurement and repair for OEMs, PCB assemblers, aviation & defence, R&D, scientific & medical, education, contract manufacturing and service & repair.

Australian Technology Park is ideally located only 5 minutes south of the Sydney CBD and 15 minutes from the Airport. There is ample parking on site for visitors and there is a wide selection of accommodation close-by for visitors.

The venue also encourages exhibitors and visitors to network in a more relaxed environment and to spend more time with one-on-one discussions as often at large general shows visitors are in a hurry to get through the entire event and do not get to spend quality time with exhibitors.

Running concurrently with the industry trade show will be the "Surface Mount 2010 Conference" for electronics design and manufacture.

The show will be open from 10am-6pm on Wednesday 8 September and 9am-6pm on Thursday 9 September. Visitors can pre-register at the expo website www.electronex.com.au.

Enquiries about the Electronex exhibition should be directed to AEE on (03) 9676 2133; email info@auexhibitions.com.au and enquiries regarding the Surface Mount 2010 Conference should be directed to Andrew Pollock on (03) 9568 0599; or email pollocka@smcba.asn.au .

*** Call in and say "Hi" to SILICON CHIP on stand A28.** SC

High-performance microphone preamplifier

Some recording devices, especially computer sound cards, have poor sound quality or insufficient gain when used with certain microphones. This tiny module provides a line level output from an unbalanced or balanced microphone and has very low noise and distortion. It runs off 5-20V DC, consuming just 6mA.

By NICHOLAS VINEN

THE REASON THAT a microphone preamplifier is necessary is that most microphones, especially unpowered types, have a low output signal level. A typical microphone will deliver 10-200mV RMS at maximum volume. Audio "line level" is around 775mV RMS (0dBu) or higher but a great deal of audio equipment can actually handle 1V RMS or more. Higher signal levels usually mean more dynamic range.

So to interface a microphone to a mixer, computer sound card, amplifier etc, we need to insert a preamplifier in-between to boost the signal level. Otherwise it may be impossible to get enough volume.

Some such devices contain internal amplifiers but they don't always perform well. Their internal microphone preamplifiers can be noisy and may not provide enough gain for some microphones (ie, those with very low output levels). Many, if not most, computer sound cards do not use high-quality analog components.

Adding a microphone preamplifier does not guarantee good results, as the line level circuitry can still introduce noise and distortion but it certainly improves your chances of getting acceptable sound quality. On the other hand, a preamplifier is a necessity for connecting a microphone to any gear which only has line level inputs.

Performance

As can be seen from the specifications and graphs, this preamplifier has very good performance despite its low supply requirements. Signals below 50mV RMS will result in worse performance while higher level signals will provide better performance. For a 25mV RMS input, the signal-to-noise ratio will be reduced by 6dB, for 12.5mV by 12dB and so on. With a 100mV RMS input, the S/N ratio goes up to 94dB and THD+N improves to below 0.002%.

The performance doesn't vary with signal frequency. The frequency response is very flat with -3dB points at around 1Hz and 1MHz (see Fig.1). The total harmonic distortion plus noise (THD+N) level is the same across the audible band (see Fig.2) and at typical microphone levels consists mostly of noise.

Under our test conditions with 50mV RMS input and 775mV RMS output, harmonic distortion accounts for just 12% of the total distortion measurement and is primarily second harmonic.

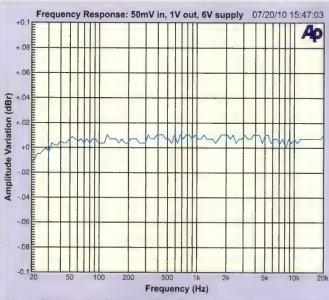


Fig.1: this graph plots the frequency response of the Mini Microphone Preamplifier. Note that the vertical scale is greatly magnified, as the frequency variation is within just ±0.01dB. This figure is at the limit of our Audio Precision System One test gear's resolution – the response is about as flat as it gets.

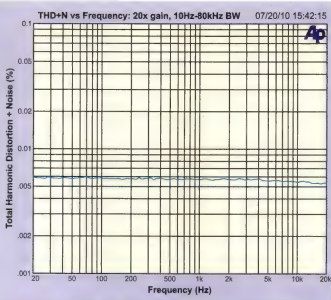


Fig.2: this graph shows the total harmonic distortion (THD) with respect to frequency. Distortion levels are higher than quoted because this is measured over a wider bandwidth (10Hz-80kHz), so more noise is registered. The slight drop at high frequencies is due to the 80kHz cut-off. Again this is essentially a flat measurement.

Such a wide frequency response is not necessary but is the result of making this project as small and simple as possible. There is no low-pass filter except for the internal compensation of the op amps. We are assuming that most devices which accept line level signals will have their own bandpass filters to remove frequencies outside the audio spectrum.

CMRR

The Common Mode Rejection Ratio (CMRR) is a measure of how well a device with a balanced or differential input is able to reject a signal that is common to both inputs. In other words, if the same amount of 50/100Hz hum is coupled into both signal conductors in the cable, this is the amount by which that hum is attenuated.

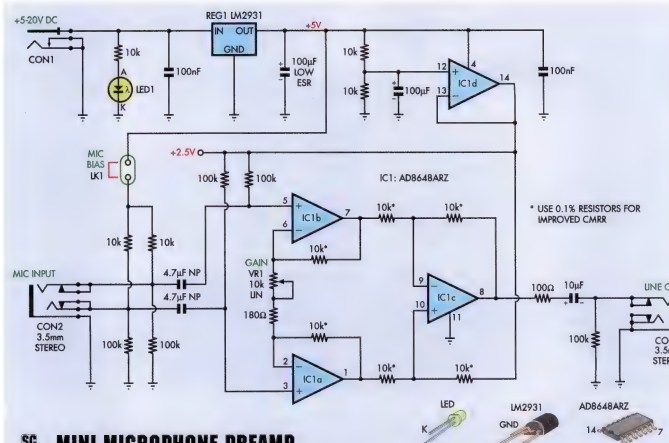
For our first prototype, we used standard 1% resistors throughout and measured a CMRR of -55dB. Our second prototype used more expensive 0.1% resistors in the differential amplifier which improved the CMRR to -88dB. In practice, -55dB is perfectly adequate unless you have a very long microphone cable run.

To get the best performance, either the power supply ground or signal ground should to be connected to earth. This reduces the possibility of mains 50/100Hz hum entering the circuit. However, you should avoid earthing both so that an earth loop cannot be created.

In other words, earth the supply ground but only if neither the input nor output signal grounds are already earthed. The diecast aluminium box

Main Features

- Unbalanced or balanced mono input (3.5mm mono/stereo socket)
- Unbalanced mono output (3.5mm mono socket)
- Very low distortion and noise
- Small and easy to build
- Runs off a 5-20V DC plugpack or battery
- Adjustable gain over a wide range
- Line level output to at least 1.5V RMS
- Provision for electret microphone bias (approx. 390μA)



MINI MICROPHONE PREAMP

Fig.3: the circuit is based on quad op amp IC1, with IC1a & IC1b forming a balanced amplifier stage. This provides the gain and drives differential amplifier stage IC1c which converts from a balanced to an unbalanced output signal. Regulator REG1 provides a +5V supply rail to power the circuit, while IC1d and the 10kΩ divider resistors on its pin 12 input provide a +2.5V half-supply rail to bias IC1a-IC1c.

is connected to ground (and therefore earth) to improve its magnetic shielding properties.

It is also very important to use shielded cables. Most of the distortion we encountered while testing the preamplifier's unbalanced performance was in the form of hum entering via the input lead. This changed depending on how the lead was routed.

We tested both the AD8648ARZ and AD8694ARZ quad op amps and found the overall performance to be the same. Use whichever one is easiest or cheapest to obtain.

Balanced input

While this circuit was designed with cheap, unbalanced microphones in mind, it is able to handle balanced signals too. These have the advantage of good noise cancellation, eliminating hum, especially with long cable runs. However, because the unit is so small we cannot fit the standard XLR type connectors. Instead, we are using the tip and ring of a 3.5mm stereo connector for the positive and negative balanced signals respectively.

If you intend using unbalanced microphones, we assume that they will be fitted with a mono 3.5mm jack plug. Inserting this into the 3.5mm stereo socket will ground one side of the balanced input, to give unbalanced operation.

To test its balanced capabilities, we used an XLR to 6.5mm Tip-Ring-Sleeve (TRS) cable with a 6.5mm-to-3.5mm stereo adaptor on the end. Both XLR and 6.5mm TRS connectors are used for balanced audio connections on professional gear, so getting such cables is easy enough. Unfortunately, professional gear does not come cheap. The cable probably cost more than the preamplifier!

Using a balanced input cable isn't strictly necessary but our tests showed that it is by far the best way to eliminate mains hum from the equation. With an unbalanced input cable, we could only eliminate the hum by watching the signal on the oscilloscope and moving the cable around until the 50Hz component disappeared. In practice, hum will always be a problem when using unbalanced microphones. Substituting a balanced cable (and signal) completely eliminates it, regardless of the cable routing.

Note that the metal enclosure is less critical if you are using a balanced microphone. This is because the low-level signals on the PC board are all differential – by the time the signal is converted to unbalanced, it has already been amplified so mains interference is less of a problem. With a balanced signal, even if the PC board is mounted in a plastic enclosure, performance should be good. Tests at our office show no loss in performance running the bare board with a balanced input signal.

Op amps

The AD8646/7/8 and AD8691/2/4

op amps we have used in this project provide excellent performance from a low supply voltage. They both feature a low input noise of 8nV/√Hz – the same as an OPA2132/4. This is not quite as good as an NE5532, NE5534 or LM4562 but it is impressive nonetheless, especially as they operate from such low supply voltages.

The AD8648 has a gain bandwidth (GBW) of 24MHz while the AD8694 has a GBW of 10MHz. The AD8694 features a THD+N figure of 0.0006% and a low input offset voltage of 400µV (with low drift), while the AD8648 can deliver 120mA from its outputs and handles 600Ω loads gracefully. Both have very low input bias current (<1pA) and low quiescent supply current (<2mA per amplifier).

Both op amp series are only available in surface-mount packages – Small Outline Integrated Circuit (SOIC) or the finer-pitched Thin Shrink Small Outline Package (TSSOP) or Mini Small Outline Package (MSOP). That is the trend these days and many modern, high-performance ICs are no longer available in through-hole packages. Having said that, these SMD packages are reasonably easy to solder.

These op amps are ideal for high-quality audio processing in battery-operated equipment. The AD8646/7/8 (single/dual/quad version) can even do a decent job of driving a headphone load. In this application, we have chosen them primarily for their low noise and distortion, as well as their reasonable price.

Specifications

Supply voltage: 5-20V DC (operates at 2.8-5V with reduced performance)
Supply current: typically below 6mA
Voltage gain: 3-111
Input sensitivity (line level output): 14mV RMS
Input sensitivity (1V RMS output): 18mV RMS
Input impedance: 50kΩ (8.3kΩ with bias enabled)
THD+N ratio: 0.0035%
THD+N ratio (10mV RMS in): 0.014%
Signal-to-noise ratio: -90dB (-93dB A-weighted)
CMRR* (1% resistors): -55dB
CMRR* (0.1% resistors): -88dB
Frequency response: 20Hz-20kHz ±0.01dB
Signal handling: 500mV RMS input, 1.5V RMS output
Signal handling (3.0V supply): 330mV RMS input, 1.0V RMS output

Note 1: CMRR = Common Mode Rejection Ratio
Note 2: all specifications relative to 50mV RMS input, 775mV RMS output, 20Hz-22kHz bandwidth and a 6V supply, unless otherwise stated.

Circuit description

Refer now to Fig.3 for the circuit details. As shown, power is supplied via PC-mount DC socket CON1, with green LED1 indicating operation. The 10kΩ current-limiting resistor is a much higher value than usual and as a result, the LED glows dimly. This is done to conserve power if the preamplifier is being run from a battery. If you don't plan to use a battery or don't mind a few milliamps of extra current drain, then you can change the 10kΩ resistor to 1kΩ so that the LED is brighter.

Since the LED runs off the unregulated supply, its brightness will depend on the supply voltage. This means that it can also be used as a crude battery level meter.

Regulator REG1 is an LM2931 low-dropout (LDO) type, so its output voltage is stable with an input as low as 5.1V. Its quiescent current is typically below 1mA, again contributing to good battery life. Below 5.1V, REG1 ceases regulating but the circuit can still run, as long as the input supply is at least 2.8V. However, the maximum output signal level is lower with a supply below 5.1V. With a 2.8V supply, the maximum output level is 950mV RMS, which is still above line level.

There is no supply polarity protection diode as REG1 can withstand negative voltages and its input filter capacitor is a non-polarised type. The 100µF capacitor at its output filters the regulated voltage and is necessary for stability. Because REG1 is an LDO type, the output capacitor must be at least 100µF and its Equivalent Series Resistance (ESR) has to be between 0.03Ω and 1Ω. That is why we have specified a low-ESR type (listed as 0.22Ω).

In reality, many other 100µF capacitors are probably suitable but they would need to be tested using an ESR meter before installation to ensure that they are within the acceptable range.

The two 10kΩ resistors between REG1's output and ground form a voltage divider, the junction of which is at half the supply voltage (normally +2.5V). This is necessary because the op amps use ground as their negative rail. Their input and output AC signals must be biased to this virtual ground potential so that the signals always stay between the two supply rails (5V and 0V).

The second 100µF capacitor filters this virtual ground. This is important as otherwise supply noise could couple into it and noise on the virtual ground will couple directly into the signal path. The half-supply voltage is fed into op amp IC1d which is configured as a voltage follower. Its output is the same voltage as its input but has a much lower impedance, so any current fed into the virtual ground has no effect on its level.

The two input signals at 3.5mm socket CON2 (one of which is grounded with an unbalanced microphone) are DC-biased with 100kΩ resistors in case the signal source is floating. If a jumper link is placed across LK1, these signal lines are pulled up via 10kΩ resistors to provide a 390µA bias current for an electret microphone – see panel. Regardless of the DC biasing, the signals pass through the two 4.7µF non-polar AC-coupling capacitors.

Next, the signals are biased to a DC level of 2.5V by two 100kΩ resistors and then enter the differential amplifier. Op amps IC1a, IC1b and IC1c are configured in the classic instrumentation amplifier layout. IC1a and IC1b have a high impedance input and

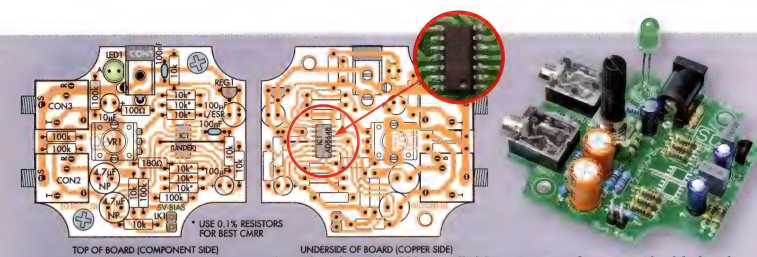


Fig.4: here's how to install the parts on the PC board. IC1 should be installed first – it goes on the copper side of the board and must be orientated with pin 1 at bottom right (see photo). The jumper is installed for LK1 only if you intend using an electret microphone – see panel. Note that prototype board shown in the photo differs slightly from the final version.

provide the gain which is varied by potentiometer VR1.

VR1 and its series 180Ω resistor form a voltage divider, along with the 10kΩ resistors to the outputs of IC1a (pin 1) and IC1b (pin 7). As a result, when VR1 is turned clockwise and its resistance decreases, the gain of both IC1a and IC1b increases.

Note that, in each case, the "bottom end" of the divider network is not connected to ground but rather to the output of the opposite op amp. This provides much better common-mode rejection. That's because the gain of each op amp can vary due to resistor tolerances but since the gain is differential, it does not matter.

The buffered and amplified signals are now passed to IC1c which is connected as a differential amplifier. It converts the balanced signals from IC1a & IC1b to an unbalanced signal. The resulting waveform is then AC-coupled via a 10µF electrolytic capacitor to CON3, the 3.5mm stereo output socket.

Note, however, CON3's ring terminal is grounded which means you must use a mono jack plug. The associated 100kΩ resistor references the output signal to ground while the 100Ω series resistor isolates the output from capacitive loads to ensure stability.

Construction

All the parts are mounted on a PC board coded 01109101 and measuring 56 x 49.5mm. This board has corner cutouts to clear the corner pillars in the specified diecast metal case.

Fig.4 shows the parts layout. Begin by checking the copper side of the board for any defects (cracks, short circuits, etc). Check also that it is the correct shape to fit in the box. If necessary, make the corner cut-outs using a small hacksaw and file.

Make sure that the board goes all the way down into the box. The inside of the box tapers slightly and it may be necessary to file the edges of the board so that it fits.

The next step is to solder the surface-mount IC (IC1) into place. This is a 14-pin SOIC package and is fairly easy to solder provided due care is taken. You will need a soldering iron with a fine tip and a good light (preferably a magnifying lamp).

First, orientate the PC board copper side up and with the SMD pads posi-

This view shows the completed PC board mounted inside its diecast metal case. This case makes for a rugged assembly and provides the necessary shielding.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	5	100kΩ	brown black yellow brown	brown black black orange brown
❑	11	10kΩ	brown black orange brown	brown black black red brown
❑	1	180Ω	brown grey brown brown	brown grey black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown

Biasing Electret Microphones

Electret microphones have an internal Field Effect Transistor (FET) which amplifies the very low level signal they generate. This FET requires a source of current to operate. Some such microphones contain an internal battery, in which case they can be treated like any other microphone. However others require power to be sent along the input cable, in a similar manner to "phantom power".

If you have an unbalanced electret microphone which requires external power, this unit can deliver it. A jumper shunt placed on the 2-pin header (LK1) enables the bias current. Assuming the microphone's bias voltage is 1V, it will receive 390μA. Some electrets require more current – up to 800μA – but others can be damaged if more than 400μA is supplied.

If your microphone needs more current then you can change the two 10kΩ resistors near the non-polarised capacitors to 5.1kΩ. In this case the bias current will increase to 775μA with a bias voltage of 1V.

This unit will also provide power for balanced condenser microphones, using the same 2-pin header.

tioned as shown in Fig.4. That done, apply a small amount of solder to one of the pads – eg, the upper-right pad if you are righthanded or the upper-left pad if you are lefthanded.

Now place the IC alongside the pads with the bevelled edge on the righthand side and the pin 1 dot at the bottom-right. Check that it is correctly orientated, then melt the solder on the pad (taking care not to spread it to adjacent pads) and gently slide the IC into place. Do not apply heat for more than a few seconds.

Next, press down gently on the IC and re-heat the pad, allowing the solder to melt. This ensures that the IC is sitting flat on the board. Now check that the pins are all aligned with the pads. If not, re-heat the soldered pad and slide the IC until all the pins are lined up, then apply solder to the diagonally opposite pin.

It's now simply a matter of flowing a small amount of solder onto the remaining pads. Ensure that it adheres to both the pad and the pin in each case. Generally, this is achieved by ensuring that the soldering iron remains in contact with the pad for about one second after the solder is applied. If you accidentally join any of the adjacent pads or pins together, remove the excess solder using solder wick.

Finally, apply a small amount of additional solder to the first two pads you soldered to hold the IC in place, to ensure the solder has flowed correctly. Once it's finished, use a magnifying glass to check that all the pins have been correctly soldered and that there are no bridges.

With the IC secured, the parts can now be installed on the top of the board. Begin by fitting the single wire link using 0.71mm tinned copper wire or a 0Ω resistor, then install the resistors. Table 1 shows the resistor colour codes but you should also check each one using a DMM before installing it.

If you are using 0.1% 10kΩ resistors to get the improved CMRR figure then be sure to install them in the locations marked with asterisks on Fig.4. The remaining 10kΩ resistors can be 1% types without affecting the performance.

Now mount the two 3.5mm stereo sockets. First, remove the nuts from both and discard them then press the sockets down so that they sit flat on the PC board. Check that they are aligned with the edge of the board before soldering all the pins.

Follow these with the two multilayer ceramic capacitors. They are the same value and can go in either way. The LM2931 regulator in the plastic TO-92 package can then go in. Use small pliers to bend its legs out by 45° and then back down parallel again so that they will fit through the holes in the PC board. Make sure its flat face is orientated as shown on the overlay.

The 2-pin header is next on the list, followed by the polarised electrolytic capacitors. **Check that the 100μF low ESR type goes in next to the regulator** and check that they are all orientated correctly. Don't get the 10μF and 100μF capacitors mixed up.

The two 4.7μF non-polar electrolytics can be fitted either way around. Install these now, then fit the DC power socket. The latter should sit flush with the board and its pins soldered using generous amounts of solder.

Finally, install the 5mm green LED. This goes in with the bottom of its plastic body 19mm above the PC board and its flat edge towards CON1 – see Fig.4. A strip of cardboard cut to 19mm can be inserted between its pins when soldering it in to set the correct height.

Parts List

1 PC board, 56 x 49.5mm, coded 01109101
1 die-cast sealed aluminium box, 64 x 58 x 35mm (Jaycar HB5030)
1 2.5mm PC-mount DC power socket (Jaycar PS0520, Altronics P0621A)
2 3.5mm PC-mount stereo switched socket (Jaycar PS0133, Altronics P0092)
1 2-pin header (2.54mm pitch)
1 10kΩ linear 9mm vertical PC-mount potentiometer (Altronics R1946)
1 jumper/shorting block
1 50mm length of tinned copper wire or 0Ω resistor

Semiconductors
1 AD8648ARZ or AD8694ARZ quad low noise rail-to-rail op amp (IC1)
1 LM2931Z-5.0 or LM2931AZ-5.0 low dropout 5V regulator (REG1)
1 5mm green LED (LED1)

Capacitors
1 100μF 16V low-ESR electrolytic (Jaycar RE6310)
1 100μF 16V electrolytic
1 10μF electrolytic
2 4.7μF non-polar electrolytic
2 100nF multilayer ceramic (code 100n or 104)

Resistors (0.25W, 1%)
5 100kΩ 1 180Ω
11 10kΩ 1 100Ω
Optional: use 6 x 10kΩ 0.1% for improved CMRR – see Fig.4

Testing

It is a good idea to test the board before installing it in the box. Once it's installed, it can be difficult to remove.

The first step is to install the shorting jumper on the 2-pin header if your

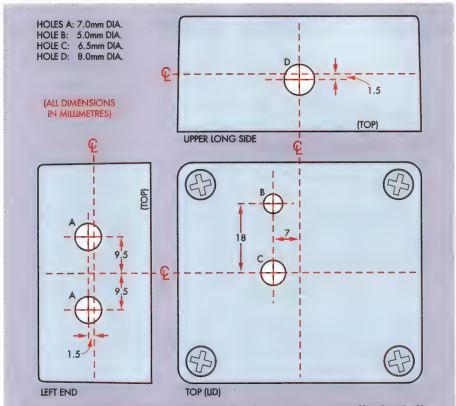


Fig.5: these are the drilling templates for the case. Use a small pilot drill to drill the centre of each hole initially, then carefully enlarge them to full size using a tapered reamer.

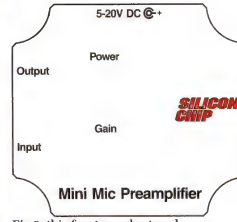


Fig.6: this front panel artwork can either be photocopied or you can download it in PDF format from the SILICON CHIP website.

microphone requires a bias current (ie, if it is an electret – see panel). That done, apply power (a plugpack is the easiest) and check that the LED lights. If it doesn't, then either the supply polarity is reversed or you have a short circuit between two tracks.

Once it has power, turn the gain all the way down and connect a signal source to the input socket. You can use a microphone or some other mono or balanced signal source. A stereo signal will not work very well however, as the two channels will be subtracted from each other by the differential amplifier.

Next, connect the output socket to an amplifier or use some other method to monitor the output signal (eg, a scope). Now slowly increase the gain control on the preamplifier and check that the input signal is being correctly fed through to the amplifier. If you are using a microphone for this test, be careful to avoid feedback between the monitoring speakers and the microphone.

Final assembly

Assuming all is well, use the drilling templates shown in Fig.5 (also available on the SILICON CHIP website) to make the five holes in the diecast box. It's best to initially drill the centre of each hole with a small-diameter bit (eg, 3mm) and then carefully enlarge them to full size using a tapered reamer (this will ensure that they are accurately placed). Deburr each hole using an oversize drill.

Once the holes have been made, insert the board with the two 3.5mm sockets angled downwards. Push these into the appropriate holes and then lever the board down. The DC socket should clear the edge of the box, allowing you to lay the board flat on the internal "shelves".

If it won't go in, you may need to either file the board edges where it is catching on the box or slightly enlarge the holes for the 3.5mm input and output sockets.

Once the board is in, secure it in position with the two screws provided with the box. Now, using a multimeter set on continuity mode, check that the board ground is electrically connected to the box. You can use the exposed metal tab on the side of the DC socket as a ground test point.

It is also a good idea to ensure that there is no short circuit between the exposed wire link on the top side of the PC board and the box, or between the exposed tab on the rear of the DC socket and the box. If there is, your power source will be shorted out when it is plugged in.

If you do get a short, remove the PC board and check for any leads or other metal pieces sticking out the underside which may be contacting the box.

Assuming there are no short circuits, plug your power source back in and check that the preamplifier still works. If not, there may be a short circuit from one of the signal paths to the box for the same reason stated above. The board has been designed so that the component pads clear the box edges and shelves (except for the ground track) but there may be some circumstances under which they can make contact.

All that remains now is to fit the front panel and attach the lid. You can either photocopy the artwork shown in Fig.6 or you can download it in PDF format from the SILICON CHIP website and print it out. It can be protected using wide strips of clear tape (or laminated) and attached using a smear of silicone sealant.

The gain control shaft and LED should project through the holes in the lid by a few millimetres – just enough to allow the gain control to be adjusted with your finger tips while making it difficult to accidentally alter it if it is bumped.

If you wish, you can press the provided neoprene seal into the recess underneath the lid just prior to fitting it. However, the holes drilled earlier mean that the box is no longer dustproof or waterproof. SC

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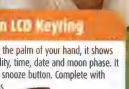

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HS-9004 Note: iPhone® not included

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Ultrasonic Antifouling System

Refer: Silicon Chip Magazine September/October 2010

Many of you know that you can buy $3-8,000 imported marine growth electronic antifouling systems. Jaycar, with Silicon Chip have developed a similar system based on this technology and information in the public domain. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in sturdy polyurethane housings. By building yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer , potting and gluing components and housings. Research reveals only one transducer is needed for boats under 40ft. Basically all parts supplied in the project kit including wiring.

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- Available end of September - call first for availability

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Record cassette tracks to your computer via USB or play back through the built-in SW speaker. You can also run the line level outputs to an external amplifier and use it as a component cassette deck.

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Ideal for podcasting or creating a YouTube masterpiece. No drivers required, just plug and shoot. Built-in microphone included for adding sound.

- 2MP
- Plug-and-play

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Hearing Loop Receiver Kit

Refer: Silicon Chip Magazine September 2010

A hearing loop is an inductive assisted listening system for the hearing impaired. They're typically installed in venues such as churches and conference rooms to enable listeners to receive in-ear communication via a wireless induction loop. You can now install this technology on your own TV, home theatre or hi-fi system. This will enable someone who's hard of hearing to hear at their own volume level without having to turn the volume up to a level too high for everyone else. The receiver will drive a pair of headphone or earbuds from the signal picked up from the hearing loop. The whole unit is completely self-contained and can be carried around in a pocket or you can add a belt clip, so the user isn't constrained by a set of headphone leads. The kit is complete with case, label, PCB and components.

Note: Transmitter not included

- Current consumption: 10mA
- Frequency response: 100Hz - 5kHz
- S/N ratio: 67dB
- Battery voltage indication: Down to 7V

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GT-3674 WAS $299.00

$269.00
SAVE $30.00

Truggy
• Length: 460mm
• Wheelbase: 275mm
• Track: 250mm
• Gear ratio: 1:8.038
• Battery: 7.2V, 2000mAh
GT-3676 WAS $329.00

$279.00
SAVE $50.00

Great Gift Idea For Father's Day

GT-3674

GT-3676

Spare parts available separately

Accessories & Upgrades For Electric Car Range

1:10 Scale Car Brushless Motor / Electronic Speed Controller Upgrade

Add serious tyre-shredding, wheel-standing horsepower to your 1:10 scale electric RC car. The kit comprises two parts - a 3300rpm/Volt brushless motor and 75amp electronic speed controller (ESC) - and will fit our GT-3670 and GT-3672, or just about any 1:10 scale RC racing car. This brushless motor and ESC combination can be powered by a normal 7.2V Ni-MH RC battery pack, but we seriously recommend using our SB-2310 3300mAH 7.4V LiPO battery pack to get the most from this serious upgrade to your RC car. See our website for a video demo of the awesome performance of this upgrade in the Jaycar carpark.

Electronic Speed Controller specifications:
• Low battery voltage cut-off to protect LiPO batteries from damage
• Over temperature protection
• Max current - 75A
• Battery Input - 7.2V Ni-MH, or 7.4V Li-Po

Motor Specifications:
• Standard RC540 size motor (36mm x 50mm)
• Brushless motor - 3300 rpm/Volt
• Shaft Diameter - 3.175mm (1/8")

GT-3675

$199.00

7.4V 3600mAh Lithium-Polymer Battery Pack

Li-Po batteries offer excellent performance compared to Ni-Mh and Ni-Cd batteries and can be consistently charged & discharged at a much higher rate. They are also smaller & weigh far less. This particular battery pack is the perfect upgrade for 1:10 scale electric remote control cars, & features standardised sizing & output cabling that are common with most 1:10 scale car batteries.

Voltage: 7.4V
Capacity: 3600mAh
Discharge rate (cont.): 20C
Discharge rate (burst): 40C
Charge input: 3-pin balance connector
Output: 12AWG silicone fly leads with Deans connector
Dimensions: 137(L) x 45(W) x 23(H)mm
SB-2311

$99.95

6.0V 1600mAh Ni-MH RC Receiver Battery Packs

The perfect solution to constantly replacing the receiver batteries in your RC car. Available in two types, "hump pack" and "flat pack", to suit almost any RC car application. Each has five 1.2V 1/3A 1600mAh cells, and are fitted with standard 2-pin JST connectors.

6.0V Ni-MH 1600mAh Hump Pack Receiver Battery SB-2302
Dimensions: 52 x 32 x 32mm, 60mm lead

$29.95

6.0V NiMH 1600mAh Flat Pack Receiver Battery SB-2304
Dimensions: 86 x 32 x 17mm. 80mm lead

$29.95

RC Fail-Safe

Fitting a fail-safe device into your nitro powered cars and boats will give you added peace of mind. If you lose radio control, your throttle servo will return to a neutral position. Lead length 100mm.
DC-1504

$24.95

7.2V Ni-MH 2000mAh RC Battery

High capacity, high current discharge Ni-MH packs for radio control cars. Fitted with standard "Tamiya" type plug.

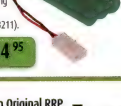
7.2V Ni-MH 2000mAh R/C Battery SB-2312 $34.95
7.2V Ni-MH 3300mAh R/C Battery SB-2314 $49.95

FROM $34.95

7.2V 700mAh Ni-MH RC Battery Stick Pack

A great value long-lasting rechargeable Ni-MH battery pack for radio controlled cars, including our 1:10 scale RC Ferrari Enzo (GT-3210) and Ferrari F430 (GT-3211). Fitted with standard Tamiya type plug.
SB-2306

$14.95



RC Helicopter Bargains

3 Channel Shark Helicopter with Alloy Frame

All aluminium airframe, fuselage and landing gear make this chopper more than a toy and suitable for outdoor flying in calm conditions. A great challenge for the more experienced pilot.

Great Gift Idea For Father's Day

• Li-Po battery recharges in about 20 minutes to give about 10 minutes flight time
• Remote requires 4 x AA batteries
• Trim control
• Plugpack charger included
• 380mm long
• Recommended for ages 14+
GT-3380 WAS $79.95 Limited Stock

$69.95
SAVE $10.00

2.4GHz Mini 4 Channel Helicopter

Very stable and easy to fly, probably the best chopper we've had so far. Four channels gives you complete control for complex and accurate manoeuvring, takeoff and landings. The body is made from Lexan so is very flexible and strong.

• 18 minute charge gives about 10 minutes flying time.
• Remote requires 4 x AA batteries.
• Measures 185(L)mm approx.
• Recommended for ages 10+
GT-3384 WAS $149.00

$119.00
SAVE $30.00

2.4GHz 3-Channel RC Car Remote

Never worry about having the right crystal again. You can save all of your models and setups in one transmitter, and recall them with a couple of button pushes. Each model memory has fully programmable features such as throttle and steering curves, ABS, traction control, steering limits and much, much more. Available as a transmitter and receiver system that includes: 2.4GHz transmitter, receiver and servo battery holder. Additional 2.4GHz 3-channel receivers are available separately
(Cat no. DC-1502 $79.95).

• 3 channel
• 2.4GHz
• Race timer
• Auto Start function
• Anti-skid braking
• Programmable throttle and steering curves
DC-1500

$149.00

Deans Style 60A 2 Pole Gold Plated Connector Set

These are the industry standard in high performance connectors. Rated number one by RC Car Action, the world's leading RC car racing magazine. These connectors offer considerably less resistance than their competitors and are rated at 60 amps. Supplied as a pair.
PT-4450

$3.95

All Savings are based on Original RRP
Limited stock on sale items.

DON'T JUST SIT THERE, BUILD SOMETHING

Happy Father's Day!

USB Turntable with Amp

Copy your LPs, 45s or even 78s straight to your PC, or simply listen to your record collection via the built-in amp and speakers. Finished in contemporary white piano finish with blue LED accents.

- RCA line outputs
- USB cable and software included
- Contemporary looks
- Measures: 320(W) x 265(D) x 85(H)mm

GE-4056 WAS $99.00

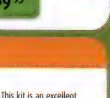
$89.00

SAVE $10.00

Great Gift Idea For Father's Day

Talking Swear Box

Tired of people around you swearing and can't get them to stop? Introduce them to the talking swear box and they will soon change their bad habits.



- 3 x LR44 batteries included
- Dimensions: 160(W) x 105(H) x 60(D)mm

GH-1316

$9.95

Solar Kits

Mini Solar Bullet Train Kit

All aboard the solar bullet train! This kit is an excellent way to teach how solar power is used to drive a small motor. Perfect for train enthusiasts!

- Includes 18 parts, 4 screws, and 1 mini solar panel
- Suitable for ages 10+

KJ-8929

$14.95

Solar Powered Planetarium

Easy to build and loads of fun. Not only does it provide a hands-on lesson about how solar power drives a motor, but also gives some educational pointers on planets and the solar system. Operates from a 50W halogen light as well. See website for full kit contents. Suitable for ages 10+

KJ-8927

$24.95

3-in-1 Solar Robot Kit

This 3-in-1 solar robot kit easily transforms into three intergalactic robotic designs. See how solar power drives the motor forcing these 3 robots to make different movements. If it's a cloudy day, then have some indoor fun and use a 50W halogen light. Projects include a tank, robot and a scorpion.

•Suitable for ages 10+

KJ-8928

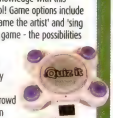
$24.95

Interactive Music Quiz

Test your family and friends' music knowledge with this interactive music quiz that you control! Game options include 'name that track', 'beat the intro', 'name the artist' and 'sing the next line'. Or make up your own game - the possibilities are endless!

- Speaker console with speaker, four team buzzers and LCD points display
- Quizmaster controller with music start/stop button, points buttons, crowd sound effects, three music distortion buttons and volume control
- MP3 player (not included) connection to the Quizmaster controller
- Requires 3 x AA batteries
- Suitable for ages 8+

GE-4233 WAS $39.95



$34.95

SAVE $5.00

Sabre SFX LED Sword

Challenge your friends in an intergalactic battle and bring balance to the force. Extremely light and durable, made of tough acrylic to take all the knocks of travelling around the galaxy at light speed. Sound and light effects.

new

Size: 710(L) x 48(Dia)mm

GH-3520

$19.95

Sudoku Toilet Paper

Forget about reading National Geographic while you're indisposed - just play with the sodoku loo roll! When finished, put it to good use!

- Double ply for comfort

GH-1508

$5.95 Per roll

Sports Stopwatch

A great Father's Day gift for the active Dad! It's a handy sports timer that will be a useful addition to any sports bag.

- 1/100th second timing
- Water resistant
- Split time, alarm and calendar
- Includes 600m lanyard
- Dimensions: 55 (W) x 65 (H) x 15 (D)mm

XC-0270 WAS $12.95

$9.95

SAVE $3.00

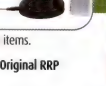
USB Plasma Ball

As the ball becomes energised, the gases inside light up and turn into plasma. By touching the outside of the ball, it will produce amazing effects.

System requirements:

- Windows XP or Mac OS X
- USB 1.1 port
- Dimensions: 130(H) x 100(W)mm

GE-4089 WAS $19.95



$14.95

SAVE $5.00

Buy Dad His Very Own Ferrari!

Superbly detailed and fully factory licensed, these RC Ferraris will give hours of fun for all ages. Pick from either 1:20 or the huge 1:10 scale Ferrari. They have 3 channels so you can race against each other, full function remote control and adjustable steering bias. Each has a rechargeable battery pack included for the car.

1:10 Scale RC Ferrari GT California

- 3-Channel
- Remote requires 1 x 9V battery

GF-3203 Was $89.95

$79.95

SAVE $10.00

Great Gift Idea For Father's Day

1:20 Scale RC Ferrari 2008 F1

- 3-Channel
- Remote requires 2 x AA batteries

GF-3207 Was $54.95

$39.95

SAVE $15.00

SnapMusic Audio Capture for PC

Turn your PC into a mini recording studio. Record and archive music from your old vinyl records, cassettes or any other audio source directly to your PC and save the files as high-quality WAVs or MP3s. See website for full specifications.

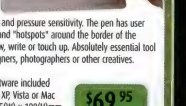
- Audio capture box with line-in/out, S/PDIF in/out and mic-in all-in-one
- Create your own podcasts from any program material
- Record live performances or lectures
- Convert audio files formats
- Burn high quality audio CDs
- Includes SnapMusic Studio 715 and Roxy Easy Media Creator 9 LE

XC-4994

$89.00

5.5" Graphics Tablet

Using a graphics tablet is completely natural, more comfortable and far more accurate than a mouse, with higher resolution and pressure sensitivity. The pen has user defined buttons and "hotspots" around the border of the tablet. Paint, draw, write or touch up. Absolutely essential tool for graphics designers, photographers or other creatives.



- Battery and software included
- Windows 2000, XP, Vista or Mac
- Dimensions: 205(W) x 190(H)mm

XC-0356

$69.95

www.jaycar.com.au

Limited stock on sale items.

All Savings are based on Original RRP

Jaycar Electronics

Better, More Technical

New Thermometers

Jumbo Display In/Out Thermometer

One display that shows both the inside and outside temperatures simultaneously. It will also record the minimum and maximum temperatures. The outside temperature sensor is waterproof and is on a 3 metre cable. It also has a tilting bail for standing as well as a keyhole for wall mounting. Jumbo digits for the optically challenged.

- Reads Celsius or Fahrenheit
- Temperature range: -39.9°C to 49.9°C -39.8°F to 122°F
- Requires AA battery
- Size: 95(W) x 140(H) x 22(D)mm

QM-7310

$19.95

Jumbo Display Thermometer/Hygrometer

Displays the temperature and humidity together on the one huge LCD display. It also has a min / max function (memory). Switch between C° and F°. Requires a AAA battery.

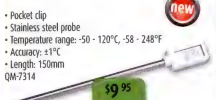
- Temperature: -10° - 60°C (14° - 140°F)
- Humidity: 10 - 99% ±5%
- Accuracy: ±1°C, ±1.8°F
- Size: 110(H) x 100(W) x 22(D)mm.

QM-7312

$24.95

LCD Probe Thermometer

Multi-purpose digital thermometer for the kitchen, lab, factory, workshop or barbeque. It measures in Celsius and Fahrenheit and fits in a pocket.



- Pocket clip
- Stainless steel probe
- Temperature range: -50 - 120°C, -58 - 248°F
- Accuracy: ±1°C
- Length: 150mm

QM-7314

$9.95

Indoor Desk Thermometer

Handy desk or table-top thermometers. Measures degrees Celsius with hi and low memory. Tilting bail for standing on desk purposes. Indoor only or indoor/outdoor type. Battery included.

Indoor QM-7316 $5.95
Indoor/Outdoor QM-7318 $6.95

- Range: -20 - 50°C
- Size: 64(W) x 72(H) x 18(D)mm

FROM $5.95

Pencil Butane Torch

Pocket sized gas torch for heatshrinking, soldering etc and uses standard butane gas. Adjustable flame, all metal construction.

- Size: 205(L) x 13(Dia)mm

TS-1667

$11.95

Non-Contact AC Voltage Tester with Torch

About the size of a marking pen, this non-contact tester detects AC voltages from 100 - 600V. It can be used for detecting live mains in outlets, powerboards or insulated wiring. It also has an LED torch and a handy pocket clip. A must for every toolbox.

- Red LED and audible voltage indicator
- Requires 2 x AA batteries (not included)
- CAT III rated
- Dimensions 180(L) x 20(D)mm

QP-2271 WAS $19.95

$14.95 SAVE $5.00

30 Piece Tool Kit with Case

Minor DIY repairs are a breeze with this 30 piece tool kit and every DIYer should have one of these in easy reach. The tools are held securely in a zip-up case. Cutters, pliers, tape measure, sockets, screwdriver bits and more. See website for detailed contents.

- Case measures: 210(L) x 160(W) x 48(H)mm

TD-2166

$24.95

Ratchet Crimping Tool for BNC/TNC Connectors

A heavy duty tool for crimping BNC/TNC connectors onto RG58/59/62 coax cable. The tool features a secure ratchet mechanism for accurate and reliable crimps.

TH-1846 WAS $39.95

$24.95 SAVE $15.00

Ultra High Current Fuses

Patented technology designed for high current protection up to 250 amps found OEM on Ford, GM and Chrysler vehicles. Slo-Blo® feature eliminates nuisance blowing during temporary, short duration overloads. Commonly used for battery and alternator connections and other heavy gauge cables requiring ultra high current protection. Rated up to 32V AC or DC. Terminal studs 8mm.

High Current Fuse Holder	SF-1980	$19.95
Bolt-Down Fuse 125A	SF-1982	$9.95
Bolt-Down Fuse 250A	SF-1984	$9.95
Bolt-Down Fuse 500A	SF-1986	$9.95

FROM $9.95

Cable Stapling Guns

Great Gift Idea For Father's Day

Cable Stapling Guns

Take the pain out of cable installation. Instead of trying to pound away with a hammer, simply staple the cable to eaves, rafters or joists. The staples have an integral plastic cable clamp that holds the cable firmly in place. Each gun takes a variety of staples sizes to accommodate cables up to 12.5mm diameter.

Cable Staple Gun 4-10mm	TH-2610	$19.95
includes gun, 2 interchangeable blades and 200 staples.		
Heavy Duty Staple Gun Kit 4-12.5mm	TH-2615	$49.95
Includes heavy duty die cast gun, 3 interchangeable blades and 200 staples in a carry case.		
Cable Staples Refill 4-6mm Pk 200	TH-2611	$9.95
Cable Staples Refill 6-8mm Pk 200	TH-2612	$9.95
Cable Staples Refill 8-9mm Pk 200	TH-2616	$9.95
Cable Staples Refill 9.5-11mm Pk 200	TH-2617	$9.95
Cable Staples Refill 11.5-12.5mm Pk 200	TH-2618	$9.95

Staple Guns From $19.95

Staples From $9.95

Rotary Tool Kit with Flexible Shaft

Flexible shafts have a multitude of uses. The kit consists of a powerful 32,000 RPM rotary tool that Dad can use with numerous attachments in the usual way, plus a 1m long flexible shaft that attaches in seconds to give extra versatility. Suitable for model making, automotive, workshop, art, jewellery or sculpture.

Great Gift Idea For Father's Day

- 135W
- Over 200 accessory pieces
- See website for full kit contents
- Size: 210(L) x 52(Dia)mm

TD-2459

$44.95

Heavy Duty Wire Stripper / Cutter / Crimper with Wire Guide

Designed for easy wire stripping of AWG 10-24 gauge cable (0.13 -6.0mm). The wire guide ensures the correct length is stripped a precision blade is incorporated for easy wire cutting. Also features quality crimping jaws.

- For 1.5 - 6mm terminals
- Spring return

TH-1827 WAS $29.95

$19.95 SAVE $10.00

Gaming Console Tool Kit

If you have ever attempted any repair or improvement on your gaming console, you know that the right tools an make the difference between a good experience and a bad on. Everything you need to get into your gaming console and accessories. Includes tools for pretty much every console and handheld on the market today - Wii, X-Box, Playstation etc. Carry case included. See website for full contents.

TD-2109

$29.95

Micro Blade Fuses 10pk

Micro-blade fuses to suit newer model cars. The pack contains one each of 5, 7.5, 25, 30A and two each of 10, 15, 20A.

SF-2146

$9.95

All Savings are based on Original RRP
Limited stock on sale items.

DON'T JUST SIT THERE, BUILD SOMETHING

Happy Father's Day!

Screwdriver with 10 Bits & Light

LED illuminated bit driver for working in spaces with poor lighting. The handle has four LEDs built in to provide working light. 10 bits are included, but any standard hex bit will fit. Great for fiddling around under the bonnet etc

- Four LEDs to eliminate blind spots
- Bits included: PH #0, #1, #2, slotted 3, 4, 5mm, T15, M6 pin drive, M4 hex, hex - 1/4" square converter
- Batteries included, plus a spare set

TD-2091 WAS $22.95

$14.95 SAVE $8.00

188pc Rotary Tool Accessories Pack

At substantially lower cost than the hardware store brands and with 188 pieces, this kit will service every rotary tool bit you'll ever need. Everything is housed in a case so you can see exactly where all the bits belong. Sanding, grinding, cutting and polishing attachments. See website for full list of contents.

TD-2458

$19.95

Rechargeable Solar DMM

An environmentally friendly DMM with rechargeable batteries that can be charged from the built-in solar panel, 12-36VDC or from mains power. Never have to buy batteries again.

- Category: Cat III 600V
- Display: 2000 count
- Size: 179(H) x 88(W) x 39(D)mm

QM-1546 WAS $119.00

$95.00 SAVE $24.00

Sound Level Datalogger

Designed for recording and logging sound pressure level measurements for quality control, illness prevention, acoustic design or any other type of environmental sound measurement in domestic or industrial applications. The memory is able to record up to 129,920 samples with A or C weighting at intervals from 1 second to 24 hours and downloaded to a PC for later analysis. Modified to calculate SPL via proper log averaging rather than the inaccurate arithmetic average used on the original design. Battery and windsock included.

- USB interface
- Over-range indication
- System requirements: Windows 2000, XP, Vista.
- Dimensions: 140(L) x 28(W) x 21(H)mm

QM-1599

$149.00

Great Gift Idea For Father's Day

Multifunction LED Controller with Remote

Great for applications like back lighting, mood lighting and commercial signage. Comes complete with a wireless remote control, so you can adjust your LED effects from a distance of up to 50 metres. Features adjustable 12 modes, 8 speeds, pause and brightness control. Unit requires 12-24V supply and will provide up to 5A maximum load per channel. See our website for compatible LED modules.

Dimensions: 211(L) x 40(W) x 30(H)mm

MP-3275

$79.95

Professional Laser Distance Meter

Distance, area, volume or indirect measurement, this does it all in metres, feet or inches. It also adds, subtracts and takes min/max measurements. Invaluable for architects, estimators, builders or renovators. Battery and case included.

- Backlit LCD
- Laser accuracy
- Dimensions: 110(L) x 47(W) x 28(H)mm

QM-1621

$199.00

Outdoor IP65 Rated Tri-tech Microwave/PIR Sensor

Most PIRS are generally not suitable for outdoor use. The dual lenses, use of two synchronised PIR sensors and microwave technologies, plus the movement detection algorithm built in reduces false alarms and with the IP65 rating makes this sensor suitable for outdoor security applications. It also has NO and NC alarm outputs, tamper switch and LED alarm trigger indicator. See website for specifications.

- All-in-one motion sensor
- Automatic background analysis
- Selectable PIR & microwave sensitivity
- 12VDC power
- Dimensions: 168(H) x 95(W) x 65(D)mm

LA-5042

Swivel Bracket LA-5043 $19.95

$149.00

CCTV Power Distributor Box

Makes distributing power to multiple CCTV cameras a simple matter. Simply connect a common source up to 30VDC and distribute it to up to 9 slave devices. Screw terminal connection.

- Individually protected PTC output
- Individual status LED indicators
- 1 - 30V AC or DC input
- Dimensions: 138(L) x 65(W) x 28(H)mm

MP-3351

$39.95

Biometric Fingerprint ID Access Control

Control a single door or use multiple units on a site connected to a PC via an RS232, RS485 or Ethernet connection. Software included.

- Up to 500 users
- 12VDC 3A relay output
- Requires 9VDC @ 500mA
- Dimensions: 180(L) x 82(W) x 55(H)mm

LA-5121 WAS $499.00

$279.00 SAVE $220.00

Also available

Universal RFID/Fingerprint Access Controller

LA-5122 $199.00

Electromagnetic Door Locks

Compatible with any access control system, magnetic door locks meet the most rigorous building and fire safety codes. No moving parts, instantaneous release, holding force of 180kg or 280kg. They can be surface mounted or ZL and L brackets provide for installation in wood, metal or glass doors. Both operate from 12VDC and are finished in satin anodised aluminium. Suitable for in-opening or out-opening doors, mounting hardware and drilling templates included.

180kg Electromagnetic Door Lock

Size: 170(L) x 41(W) x 21(H)mm Cat. LA-5060 $79.95

ZL Bracket for LA-5060 Cat. LA-5061 $39.95

L Bracket for LA-5060 Cat. LA-5062 $24.95

280kg Electromagnetic Door Lock

Size: 250(L) x 49(W) x 25(H)mm

Cat. LA-5063 $99.00

ZL Bracket for LA-5063

Cat. LA-5064 $39.95

L Bracket for LA-5063

Cat. LA-5065 $24.95

8-Zone 2-Partition Alarm Panel

With 8 protection zones including 2 zones for panic and duress alarms, the control panel is designed for home and office protection. The system gives local alarm warnings and is supplied with one alarm control panel and one master control keypad. Programmable user codes, delays and alarm duration.

- Operating voltage: 16.5VDC
- Entry delay: 15 - 90 seconds
- Exit delay: 60 seconds
- Alarm duration: 3 - 5 minutes or unlimited
- Alarm outputs: 12VDC, 2.5A
- Suitable backup battery: 12V, 7.2Ah available separately - SB-2486 $34.95
- Suitable 17VAC plugpack: MP-3022 $24.95
- Dimensions: Control panel: 168(W) x 168(H) x 78(D)mm Keypad: 117(W) x 117(H) x 27(D) mm

$169.00 SAVE $30.00

LA-5361

Note: This alarm panel includes a functional alarm dialler, however, it is not approved for use in Australia / New Zealand, as such we recommend that you do not connect it to the telephone network. LA-5361 WAS $199.00 Limited Stock

Jaycar Electronics

Better, More Technical

7" TFT Colour Monitors with Headrest

new

With these 7" LCD colour monitor headrests, kids can watch the same movie on two different monitors, or play different games on their X-Box® through the AV inputs. Both master and slave (sold separately) come with a grey headrest, & both fit easily into your car seats. Finally Dad will be able to drive in peace!

7" TFT Colour Monitor with Headrest
- Screen size: 7 inches
- Resolution: 234(H) x 480 (W) RGB
- Headrest dimensions: 270(W) x 190(H) x 140(D)mm
- Weight: 1300g

QM-3773

$199.00

7" TFT Colour Monitor with Headrest and DVD Player
- MPEG4 functions
- Supports DivX / DVD / VCD / CD / CDG / MP4 / MP3 / WMA / JPEG
- Game functions (supports 8 bit & 32 bit game)
- Supports MS/MMC/SD cards
- Easy installation in most seats
- Headrest dimensions: 290(W) x 210(H) x 130(D)mm

QM-3776

$269.00

12VDC Voltage Polarity Easy Tester

A passive, quick and easy testing solution that performs five essential tests in the field: voltage, load, polarity, voltage drop and continuity. The load applied is selectable between 1A or 500mA to test wiring depending on location, device to be tested, and anticipated voltage drop. The illuminated power connector clearly displays polarity. Ideal for CCTV and security installers, car audio, roadies, AV techs etc.

Dimensions: 51(L) x 44(W) x 29(H)mm

QP-2215

$24.95

Flush Mount Mini Waterproof Camera for Cars or Trucks

Designed for use in vehicles to give drivers a clear view of car or truck blind spots. Composite RCA cable and the appropriate sized hole saw included.

- Sensor: CMOS
- Resolution: 628 x 512 pixels
- Minimum illumination: 0 Lux / F1.2
- Camera dimensions: 31(L) x 20(W)mm

QC-3513

$89.95

new

In-Dash MP3 Player with Radio

Listen to your favourite MP3s directly from the USB/SD card slot. Featuring PLL tuner with 18FM/12 AM presets, and MP3/WMA playback you will never miss a beat with this in-dash MP3 player.

- Front USB and SD card slot
- MP3 ID3 tag display
- 4 channels x 40W MAX power output
- 4 channels x 20W RMS power output
- 2 channels x 2V line-out

QM-3781

$99.00

Great Gift Idea For Father's Day

Vehicle LED Daytime Running Lights

new

These Euro styled superbright LED bulbs will turn on automatically on ignition, making your car more noticeable on the road. With a lifespan of 50,000 hours, these long life and energy saving DRLs are a much better daytime alternative than using your fog lights or low beam headlights. Flush-mounted brackets are included for easy installation and directional tilt-adjustment.

- Energy efficient 12V 6.1W
- Emark 87R certificate
- Each lamp measures 190(W) x 30(H) x 43(D)mm

SL-3419

$149.00

Response Precision Car Amplifiers

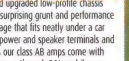
With improved heat sinks and upgraded low-profile chassis design, each model delivers surprising grunt and performance in a sleek and compact package that fits neatly under a car seat. All include gold plated power and speaker terminals and variable low pass filters. Plus our class AB amps come with variable high pass filters and pass through RCAs; while our class D subwoofer amps feature variable subsonic filter, phase shift and master/slave operation.

2 x 80WRMS Class AB Amplifier
Dimensions: 266(L) x 235(W) x 58(D)mm
AA-0450 $149.00

4 x 50WRMS Class AB Amplifier
Dimensions: 316(L) x 235(W) x 58(D)mm
AA-0451 $199.00

2 x 150WRMS Class AB Amplifier
Dimensions: 376(L) x 235(W) x 58(D)mm
AA-0452 $229.00

FROM $149.00



4 x 100WRMS Class AB Amplifier
Dimensions: 436(L) x 235(W) x 58(D)mm
AA-0453 $299.00

new

500WRMS Linkable Class D Subwoofer Amplifier
Dimensions: 232(L) x 178(W) x 58(D)mm
AA-0454 $249.00

1000WRMS Linkable Class D Subwoofer Amplifier
Dimensions: 306(L) x 178(W) x 58(D)mm
AA-0455 $369.00

Response Precision 4 x 100WRMS Full Range Digital Amplifier
Dimensions: 306(L) x 178(W) x 58(D)mm
AA-0457 $349.00

12 Month Warranty

RESPONSE

1 Watt LED Torch with In-built Car Charger Plug

Low battery? No worries, this super-bright 1 watt LED torch conveniently recharges in your car's cigarette lighter socket. With a robust aluminium alloy housing it can take a fair amount of abuse and still shine as brightly as the day you bought it.

- Dimensions: 160(L) x 35(Dia)mm

SL-3381

$19.95

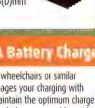
Low Voltage Battery Isolator

With microprocessor control, this indispensable device monitors the output voltage of any 12V lead-acid battery. If the terminal voltage drops below 11.9V, the battery will be automatically disconnected. Essential for boats, camping, caravans, RVs, 4WD, solar power systems etc.

- High cranking capacity - 800A
- High input/output current - 200A
- Low power consumption - 15mA
- 3 year warranty
- Mounting hardware included
- Dimensions: 85(H) x 55(W) x 35(D)mm

MB-3678

$99.95



5-in-1 Inverter / Compressor / Work Light / Charger / Jump Starter

Far more than your average jump starter this unit has an impressive set of features for a hundred different uses. Tucked in on either side are two tough insulated battery clamps for all your jumpstarting needs, on the front panel you have 2 x 12VDC cigarette lighter sockets for operating 12V appliances, a 5 LED worklight and two dial indicators for air pressure and charge status. Powered by the internal 12V 18Ah SLA battery, it even has a 200W inverter to charge your laptop, etc. See Website for specifications.

- Dimensions: 220(L) x 215(W) x 295(H)mm

MB-3594

$149.00

Great Gift Idea For Father's Day

new

Three Stage 48V 9A Battery Charger

Suitable for golf buggies, electric wheelchairs or similar applications. It monitors and manages your charging with three different stages and will maintain the optimum charge level. Compact and lightweight. Includes output cables with eye terminals to attach to your battery.

- Switchable charging modes
- Short circuit, output current, polarity and thermal protection
- LED charge status indication
- Digital Charge Display
- Input: 190 - 260VAC
- Output: 48VDC @ 9A max
- Dimensions: 298(L) x 112(W) x 60(H)mm

MB-3628

$499.00

Great for Golf Buggies

DON'T JUST SIT THERE, BUILD SOMETHING

Happy Father's Day!

High Power Wireless-N USB 2.0 Network Adaptor

Able to reach wireless networks from significant distances with enough signal strength to do what you need. The unit can connect to wireless networks up to 1.5km away. The supplied software provides you with a myriad of specifications of wireless networks broadcasting in your area.

Dimensions: 75(L) x 58(W) x 10(H)mm
Antenna: 172(H)mm
YN-8306

$69.95

Great Gift Idea For Father's Day

4 Port USB 3.0 Hub

USB 3.0 hub with four ports. 4.8Gbps data rate. 10 x faster than USB 2.0.

- Dimensions: 85(L) x 32(W) x 18(H)mm

XC-4947

$79.95

USB 5-Button Laser Mouse

All the normal mouse functions - left and right click, scrolling, plus forward, back and quick-launch button. Ergonomically shaped for fatigue-free use.

- Plug and play - no drivers required
- Windows 2000, XP, Vista, 7

XM-5240

$17.95

Rechargeable Wireless Optical Mouse

Enjoy complete freedom from the constraints of cables on your workstation when mousing around. You can use rechargeable batteries and charge via the USB lead or simply use 2 x AA alkaline batteries. The USB dongle stores away in the mouse's back door when not in use.

- Plug and play
- Windows 2000, XP, Vista, 7

XM-5246

$29.95

USB Optical Mini-Mouse

If you own a laptop or netbook, there's no doubt a mouse is easier to use than a touchpad. Take this to school, the office or on business trips. It's small enough not to take up much space, but big enough to be functional. Ideal for the kiddies first starting to use computers too.

- Scrolling wheel
- Plug and play
- Compatible with Windows 2000, XP, Vista, 7

XM-5242

$9.95

2 x USB 3.0 Port Upgrade Kit

Add two USB 3.0 ports to the front of your desktop PC for compatibility with the next generation of superfast USB 3.0 hard drives, flash drives and other assorted peripherals. The front panel will fit neatly into the 3.5" FDD slot of most PC cases. Each port has a USB 3.0 cable running from the rear which should be plugged into the ports on the supplied PCI-E card.

XC-4147

$79.95

Dual 2.5/3.5" SATA HDD Docking Station - USB 3.0

A blazing fast USB 3.0 ready dual SATA docking station for the home or office. Dock two 3.5 or 2.5 inch SATA drives or one of each, and in a flash you can back up gigabytes, terabytes or petabytes of information without the hassle of installing hard drives in enclosures or in the PC.

Dimensions: 130(W) x 61(H) x 103(D)mm
XC-4697

$99.00

Note: HDD not included.

USB 3.0 to 2.5/3.5" HDD/SSD SATA Adaptor

Collected a box full of hard drives over the years? Want a simple way to access them? This adaptor is the perfect tool. Older USB 2.0 SATA adaptors are unable to extract the full 3.0Gpbs transfer speed of SATA drives, so you're restricted to a paltry 480Mpbs. This adaptor will give you the speed you need to transfer large file in a fraction of the time.
(your PC must have a USB 3.0 port).
Compatible with Windows 2000/XP/Vista/ Win 7/MAC OS 9.X/10.X/Linux
XC-4145

$79.95

2.5" SATA HDD Enclosure - USB 3.0

Take advantage of the massive speed increase of USB 3.0. Slot a 2.5" SATA HDD into this enclosure and when connected to a USB 3.0 port of a computer you will experience speeds up to 10 times faster than USB 2.0.

- Includes one 1.1m USB 3.0 Micro B - to Male A cable
- Locking screws included
- Dimensions: 77(W) x 113(L) x 14(0)mm

XC-4684

$59.95

Line Interactive Uninterruptible Power Supply (UPS - 600VA)

Compact and completely self-contained, this is the ideal backup solution for your data or other important equipment. It has 3 surge-protected outlets as well as 3 outlets backed up by the UPS. It also has RJ11 ports for protecting phone or fax lines.

- Cold start feature
- Software included
- Rating: 375W, 600VA
- SLA battery: 7Ah
- Supply voltage 220 to 280VAC
- Backup time: 3 min at full load
- Recharge time: 10 hrs
- Output waveform: Step sine wave
- Dimensions: 268(L) x 180(W) x 80(H)mm

MP-5222

$119.00

USB 3.0 Adaptors

Plug B to Socket A Adaptor	PA-0930 $12.95
Micro B Plug to Socket A Adaptor	PA-0931 $12.95
Socket A to Socket A Gender Changer	PA-0932 $12.95
Plug Micro B to Socket B Adaptor	PA-0933 $12.95

$12.95

Mini 4 Port HUB USB 2.0

The perfect add-on to increase the number of USB ports on your computer. This unit will allow up to 4 USB peripherals to be utilised without the loss of speed. It is plug and play with auto-detection and safe removal from your USB port.

- 750mm USB interface lead supplied
- Hub measures: 83(W) x 16(H) x 32(D)mm

XC-4864 WAS $24.95

$19.95

SAVE $5.00

Great Gift Idea For Father's Day

Switchmode Mains Adaptor 3 - 13.8VDC 2.5A

Variable desktop power supply with binding post and 7 DC plugs. 1.5 metre lead with interchangeable connectors.

- Output voltage: 3, 5, 6, 9, 12, 13,8VDC
- Output current: 2.5A max
- Dimensions: 140(L) x 80(W) x 42(H)mm

Approval number: SGSEA/100289
MP-3308

$39.95

www.jaycar.com.au

Limited stock on sale items.
All Savings are based on Original RRP

Jaycar Electronics
Better, More Technical

New TV Antennas

Indoor Flat Panel UHF/VHF Amplified Digital Antenna

This flat panel indoor amplified digital antenna features low noise circuitry, multidirectional reception and auto gain control - receiving both local free-to-air analogue and digital TV as well as DAB+ digital radio signals with remarkable consistency and crystal-clear clarity. Includes 6V 100mA mains adaptor and PAL to F coaxial cable. Mount it either freestanding, on your wall or even on your ceiling in either vertical or horizontal position. Its shiny piano black finish will nicely complement your flat panel LCD or plasma TV.

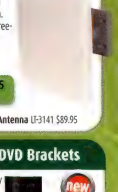
• Panel size: 227(W) x 235(H) x 14(D)mm

LF-3131

$49.95

Outdoor Flat Panel UHF/VHF Amplified Digital Antenna

A versatile space-saving outdoor antenna that's ideal for apartments or when antenna roof mounting is either too difficult or not an option. Once mounted you can easily adjust vertical and tilt position to maximise reception strength. With an integrated amplifier for enhanced reception clarity, it delivers local free-to-air analogue and digital TV as well as DAB+ digital radio programs. It also features waterproof and weather resistant ABS housing, low noise circuitry, multidirectional 360° reception and auto gain control. Includes mounting bracket, 6V 100mA mains adaptor, and PAL to F coaxial cable.



• Panel size: 281(W) x 305(H) x 20(D)mm

LF-3139

$69.95

Also available **New Outdoor Omni-Directional UHF/VHF Amplified Digital Antenna** LF-3141 $89.95

Remote Controls

Universal Learning Remote with A/C Control

Pre-programmed with thousands of devices, and able to learn and control up to 8 different devices including the AV equipment & air conditioners.

• Backlit LCD
• Low battery indicator
• Audible reminder
• Requires 3 x AAA batteries
• Dimensions: 200(L) x 55(W) x 26(D)mm

AR-1726

$37.95

Touchscreen 8 in 1 LCD Remote Control

Use the learning function or the pre-programmed code library to enrol each component or use the macro functions to program up to 100 keystrokes. For each different device, the LCD backlight is colour coded for easy recognition and you can change the device key layout as you like. Requires 4 x AAA batteries.

• Size: 195(L) x 65(W) x 21(H)mm

AR-1728 WAS $59.95

$49.95
SAVE $10.00

Great Gift Idea For Father's Day

Universal Air Conditioner Remote Control

This unit identifies over 40 preset popular air conditioning brands with digital searching but will also auto search for other brands not so commonly used.

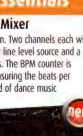
• Easy 3-step set up
• Requires 2 x AAA batteries
• Dimensions: 130(H) x 55(W) x 22(D)mm

AR-1729 WAS $24.95

$19.95
SAVE $5.00

Universal VESA Adaptor

Adapt any VESA mounting TV to any bracket. Many LCD or plasma brackets on the market are only designed to take TVs with standard 200mm or larger mounting centres, thereby limiting the range of brackets you can use with some TVs. This handy adaptor solves the problem by providing centres for 100, 200 and 300mm VESA mounts. Solid steel construction, black finish.



CW-2815

$24.95

Glass Wall-Mount DVD Brackets

Wall mount your DVD player or any other component right under your flat-screen TV. Tempered glass shelves and black anodised aluminium finish to complement modern décor. Also features cable management.

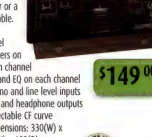
Single or double shelf models:

Single Shelf CW-2830 $69.95
Double Shelf CW-2832 $99.95

DJ Mixing Essentials

2 Channel Pro DJ Mixer

The ideal mixer to learn on. Two channels each with RCA inputs for CD or other line level source and a set of dedicated phono inputs. The BPM counter is capable of accurately measuring the beats per minute of almost any kind of dance music automatically and works equally well with a CD player or a turntable.



• Level meters on each channel
• 2 band EQ on each channel
• Phono and line level inputs
• Mic and headphone outputs
• Selectable CF curve
• Dimensions: 330(W) x 22(H) x 102(D)mm

AM-4206

$149.00

DJ Skills Mixing and Scratching Guide

Explores the history of the DJ from the radio jock to the hip-hop, rave and club generation, and the influence of jazz and other music forms on the modern DJ. It also covers tools of the trade - turntables, hard disks, drum machines, effects and mixers, as well as the skills to become a working DJ.

• Softcover, 282 pages
• 240 x 190mm.

BA-1445

$44.95

Great Gift Idea For Father's Day

USB Turntable with USB Direct Encoding

Transfer your vinyl collection directly to your USB device. Technology has never been easier. Simply play your records, plug your USB device in and click record. When finished click record again and your music is stored onto your USB - Too easy. Finished in chrome and black.

• 2 speed belt drive turntable
• 33 1/3 and 45 RPM
• Anti-skating control
• Motor off and reverse function
• RCA Phono/line output
• Dimensions : 449(W) x 145(H) x 370(D) x mm

AA-0494

$249.00

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Palmerston Nth	Ph (06) 353 8246
Wellington	Ph (04) 801 9065

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Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. Prices valid to 23rd September 2010. All savings are based on original RRP

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Jaycar Electronics
Better, More Technical

SERVICEMAN'S LOG

Electros with lumpy bits are not good

Faulty electrolytic capacitors have been a common problem in electronics gear over the last few years. In fact, some items only just make it through warranty before their power supply electros develop lumpy bits and fail.

Items Covered This Month

- DGTEC DG-HD03 set-top box
- Hot over coolant
- The bouncing modem
- Front-panel USB socket woes

Marilyn asked me to look at her DGTEC DG-HD03 set-top box (STB). The unit was barely 18 months old but the display was now stubbornly showing "8888" and nothing else. It wouldn't respond to commands from the remote and there was no output signal.

It hadn't been a sudden failure. Instead, the unit had become increasingly intermittent in operation over a period of several weeks before finally packing it in. Marilyn had tried to clear the fault by switching it off and on at the wall socket to reboot the firmware but it made no difference.

The unit was located in a TV cabinet in the living room. It rested on top of the DVD player which in turn sat on a shelf below the TV set. And one thing I noticed as it was being retrieved was

that there wasn't a lot of space between the STB and the shelf above it.

That meant that the ventilation wasn't all that great but at the time, I mentally dismissed this as being a factor. These devices don't consume much power, especially on standby, so overheating shouldn't have been a problem (or so I thought).

My initial reaction was that the fault might be due to "crook" electrolytic capacitors, probably in the power supply. I've lost count of the number of devices I've repaired over the years simply by replacing faulty electros. They're usually quite easy to spot too – they're the ones with the bulging (domed) tops.

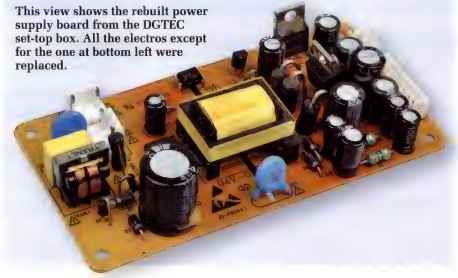
I told Marilyn that if it was something obvious such as faulty electros, then fixing it shouldn't be a problem. But if it wasn't obvious, then it would be a "bin job" as the fault would be virtually impossible to track down, especially on a double-sided PC board with lots of surface-mount parts (and no circuit diagram).

When it came time to tackle the unit, I confirmed the symptoms and checked that the batteries in the remote were OK. I then removed the case lid and took a peek inside. This revealed two PC boards – a power supply board and a much larger main board which carried the microcontroller, digital tuner, support circuitry and the various input and output sockets. And the fault was glaringly obvious – five electrolytic capacitors with bulging tops on the power supply board!

The other thing that struck me was that the varnish on the top of the power supply board had discoloured around many of the components. So it looked like it had been running hot after all and this had undoubtedly contributed

This close-up view shows the output side of the switchmode power supply. The five faulty electros with the bulging tops are arrowed.

The two 1000µF capacitors had overheated and their rubber seals were separating from the cans.



This view shows the rebuilt power supply board from the DGTEC set-top box. All the electros except for the one at bottom left were replaced.

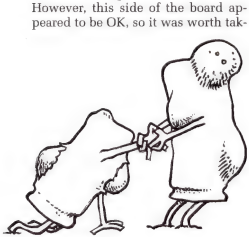
to the premature failure of the electros.

The five capacitors in question were all branded "JFD" and were sleeved in brown heatshrink. They were rated at 105°C and ranged in value from 220µF (16V) up to 1000µF (10V).

It was the two 1000µF units that had fared the worst. They had become so hot that their rubber seals had been partially ejected from the cans, leaving them sitting at odd angles on the power supply board (see photo).

Another six JFD-branded electros on this board appeared to be OK but obviously the best course of action was to replace the lot. If five out of the 11 had failed, the rest probably wouldn't be far behind.

The power supply board is easy to remove – just unplug the wiring assemblies, remove four M3 machine screws and lift it out of the case. This revealed that there were also a lot of surface-mount parts on the underside. However, this side of the board appeared to be OK, so it was worth taking a gamble on replacing the suspect capacitors.



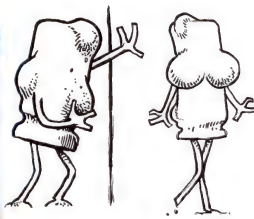
This is where my vacuum desoldering station really earns its keep. It makes removing parts a snack and it took only a few minutes to replace all the original electros with good-quality 105°C units (low-ESR types would have been preferable all round but I only had some of these). The unit was then quickly reassembled and tested with an old analog TV.

And that fixed the problem. The unit immediately fired up, responded to the remote and gave perfect pictures on all channels. In fact, the DGTEC DG-HD03 is quite a nice unit – it's built into a sturdy steel case, looks good, is easy to drive and comes with a solid remote control, unlike the cheap and nasty remotes you get with some set-top boxes.

So did the original electros fail because the unit overheated due to poor ventilation? Or were they inadequately rated for the job or was it a combination of both?

Certainly, 18 months is a pretty poor service life but it's an all too common occurrence with electrolytic capacitors these days. I've fished bulging electros out of everything from computer motherboards to ADSL modems to DVD players and this happens so often that you really have to wonder about the quality of some of these capacitors.

Just out of curiosity, I checked the power consumption of the unit. This gave figures of 9.5W when the unit was on and just 0.77W on standby. The unit had always been switched to standby when it wasn't being used but being in the living area, it had also had its fair share of use. These units can run hot, so the lack of ventilation would not have helped, especially on a hot summer's day.



Anyway, I returned the unit to Marilyn with the suggestion that the unit be placed on top of the TV set, to give it plenty of air. Electrolytic capacitors with lumpy bits are not good.

The bouncing modem

It's not only set-top boxes that have problems with bulging electros. They've long been a problem in modems as well, as this story from A. P. of Toowoomba, Qld illustrates . . .

This story began about a year ago when I replaced some bulging and leaking electrolytic capacitors in a Thomson Speedtouch 536 ADSL2 modem belonging to my friend Nick.

This time, it seemed that Nick was having trouble with his phone line. Certainly, when he called me, his voice was overlaid by a distinct hissing noise and it was apparently worse at his end.

He told me that the previous day he had submitted an online order to upgrade his Bigpond internet plan from ADSL1 to ADSL2+ but had not yet received any confirmation of when this would happen. He had also updated his modem's firmware to ensure compatibility with ADSL2+. Could either of these things be causing the hiss?

I was a little surprised at this because we had discussed the possibility of him upgrading to ADSL2+ a few days before. At that time, I had checked the availability of ADSL2+ on Nick's line by entering his phone number into the web form Bigpond provides for this purpose. It had come up negative.

I now repeated this check while we were on the phone and got the same result. As a result, I told Nick that his

proposed upgrade to ADSL2+ probably wasn't feasible and would be rejected. I also rejected the hypothesis that the problem with Nick's phone was related to the ADSL2+ software upgrade to his modem.

I then suggested that we should make sure that the problem lay in his phone line before we called Telstra to report a fault. And so I called in to his place that afternoon and we started our investigations.

Nick's house has three phone outlets, each with an in-line ADSL filter. There are phone handsets in the bedroom and lounge, while the outlet in the study is shared by another phone handset and the ADSL modem.

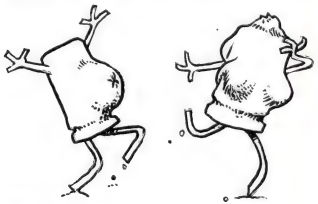
We began by checking the modular connectors on all the phones and filters and found that all the contacts were clean. We then tried different permutations of the phones and soon discovered that the hiss disappeared when we disconnected the phones in the bedroom and lounge. However, there was also no hiss when just the bedroom and lounge phones were connected and the study phone and modem were disconnected.

This all indicated a loading problem but at which end? Either the Telstra line had developed a fault or one of the devices connected to the phone line had become faulty and was imposing a higher load than normal.

Unfortunately, it wasn't possible to eliminate any given device, because we didn't have any spare phones to connect to the line. Nevertheless, I was suspicious of the modem. About a year previously, I had replaced six bulging and leaking CapXon brand capacitors in its power supply section and drilled extra ventilation holes to keep the new capacitors cool. However, I had an uneasy feeling about the replacement capacitors. They were an unknown brand at the time and although they were rated for the job, I was unsure of their quality.

Driven by curiosity as much as anything else, I cracked open the case of the modem and immediately spotted a problem. Two of the new 105°C Suntan capacitors I had installed – one 470µF and one 1000µF – were bulging and leaking! Fortunately, I had brought a spare modem with me as a precaution and in minutes it was installed and working. There was just one problem – the hiss remained and was as bad as ever.

I didn't believe that we had two faulty modems with identical symptoms, so it now looked very likely that the phone line itself was faulty. But first, I now reconsidered the possibility that Bigpond had switched on the ADSL2+ in spite of all the evidence to the contrary. However, this seemed unlikely as they hadn't even



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confirmed Nick's order yet, let alone notified him that the ADSL2+ had been activated. And of course, their own service availability form was telling us that ADSL2+ wasn't available at his address.

Next, I looked at the ADSL in-line filters Nick was using. They were all C10 Model C10245E types. I then checked the filters that had come in the box with the Bigpond ADSL2+ modem I had just installed. These were C10 Model C10245M types but for some reason, I failed to register that the model numbers were different. I did swap the filter in the study for one of the new filters but only in case the study filter was faulty.

When this didn't fix the problem I took my leave, suggesting to Nick that the fault was almost certainly in the line and that he should report it to Telstra.

Two days later Nick called me to tell me the outcome and this time there was no hiss accompanying his voice. Telstra had tested the line and found no problem. Apparently, Bigpond had turned on ADSL2+ the day after Nick ordered it and the Telstra technician who came to investigate told Nick that the C10245E filters were not suitable for ADSL2+. As a goodwill measure, he had installed an ADSL2+ central line filter without charge and this fixed the hiss problem.

With 20:20 hindsight, I looked up the FAQ on the **www.c10.com.au** website which explains that, in some cases, connecting multiple in-line filters to an ADSL2+ line results in "noise on the telephone". The newer "M" series filters (such as those supplied with my ADSL2+ modem) were designed to eliminate this problem.

As for Nick's Speedtouch modem, I replaced the faulty capacitors with good-quality Hitano units and now expect it to survive into obsolescence.

Hot over coolant

This next story is from M. S. of Niddrie, Victoria who installs and services car stereo systems. Here it is . . .

I recently repaired a CD stacker that was installed in a 1995 Ford Falcon. I'd had this stacker out for about two weeks while waiting for the parts to turn up and had then re-installed it after it had been fixed.

Unfortunately, that wasn't to be the last I would hear from this particular customer. About a week later, he rang to tell me that the engine in the car was now overheating when he accelerated or it was working under load.

So what did this have to do with me? Well, despite the fact that I had only worked on his CD player, he was blaming me for this completely unrelated mechanical problem. His reason? – I was the last person to work on the car, so it had to be my fault.

Anyway, he brought the car back and I removed the CD stacker (which was still working OK). I then checked all the earths in the car (they could be a problem in earlier models but these were OK) before refitting the CD stacker.

When he returned, I asked him if any other work had been done on the car. His answer was that it had had a full service but the overheating problem had only started when the CD stacker was refitted. And according to his convoluted logic, that meant that I was to blame.

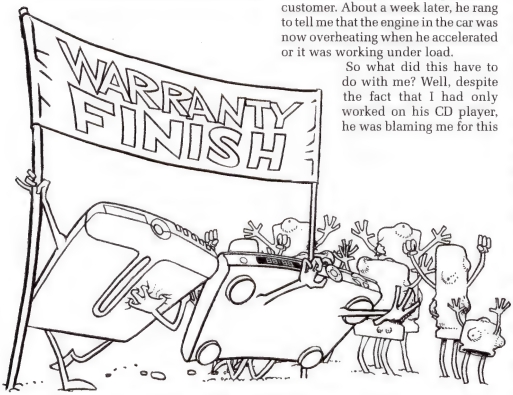
I protested that refitting the stacker could not possibly cause this problem and suggested he take the car to a mechanic to get what was clearly an unrelated fault diagnosed and repaired. However, this guy was not prepared to accept that and now goes to Consumer Affairs to get further satisfaction.

As a result, Consumer Affairs ordered further checks on the car via two motoring organisations and a well-known technical institute. The Institute found that the oil and fuel were within the manufacturer's specifications but that too much of the wrong coolant had been used. This incorrect coolant was changing the resistance of the temperature sensor as the flow rate increased with engine RPM.

So the engine wasn't overheating after all – the gauge just indicated that it was. And that certainly had nothing to do with the CD stacker repair.

As for getting a full service done by a qualified mechanic, I don't believe that happened. Instead, this bloke did what many people do with old cars – he serviced it himself and it was he who used the wrong coolant.

I wasted a lot of time on this job, trying to figure out what might have gone wrong. Unfortunately, some people will try anything to get something for nothing. It makes me wonder how they sleep at night!



SOME ITEMS ONLY JUST MAKE IT THROUGH WARRANTY...

Front-panel USB socket woes

Probably because of the way the cables are so often roughly yanked out of them, USB sockets can cause all sorts of problems on PCs. This story of one such case comes from D. S. of Maryborough, Qld . . .

The Serviceman's story on USB

woes in the July 2010 issue of SILICON CHIP reminded me of a somewhat troublesome repair which arrived on my bench some months ago. It concerned a home-built desktop PC that used a Gigabyte EP43-US3L motherboard, 4GB of RAM and an Intel CPU. It had been neatly assembled but after working correctly for quite some time, had now developed a fault.

The issue was that when the power switch was pressed, the supply would power up, the CPU fan would start and all the associated LEDs on the board and case would light – but only for about one second! The supply would then shut down and would not restart unless the mains supply was switched off and then back on, whereupon it would exhibit exactly the same symptoms all over again.

I started by disconnecting the power supply and then plugging my ATX supply tester into it. This nifty little device activates the supply and has a small LCD screen which displays all the relevant voltages. In this case, the supply came to life and all the voltages where well within limits and rock steady.

My scope also confirmed the absence of ripple which can at times upset the supply or the motherboard. So the supply was good!

Next, I turned my attention to the motherboard. I reconnected the supply to the motherboard but left all the hard drives and optical drives disconnected, along with the case fans and the light show around the front panel (just why this area of the case is lit is beyond me. I tend to look at my monitor when using my PC, not the case). However, when the power switch was pressed, the supply again quickly shut down. It was time to delve a bit deeper.

I have had issues with CPUs in the past so I substituted the CPU for a known good unit and tried again. It still powered down within about a second so I tried disconnecting the reset button, again without result. I then removed the RAM and the 12V ATX connector (the board will power up but not run if this connector is left disconnected) but it was still shutting down.

By this stage, I just had the motherboard with nothing but the main 24-pin power connector and two off-board USB connectors plugged in. And then it hit me – the USB ports in the front of the case use a 5V supply from the motherboard! I yanked the USB connectors off the board, hit the power switch again and the system sprang into life.

After shutting it down, I reconnected everything except the front-panel USB ports and rebooted. The system booted perfectly, so the front USB ports were the culprits.

Closer examination revealed that the internal contacts of one of these USB ports was damaged and in contact with the metal surround. This was shorting the 5V supply to ground and the motherboard was detecting this and shutting down the supply to prevent damage.

In hindsight, I probably should have checked the "Pwr Good" signal but all it would have told me was that the supply was being shut down by the safety circuits, not why.

Unfortunately, I was unable to buy a replacement USB sub-board. As a result, I advised the owner to purchase a USB hub with its own power pack and use that instead. SC

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in *The Serviceman* column in SILICON CHIP?

If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

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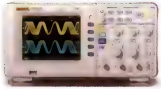

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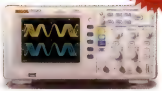

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EMONA

This receiver is designed to pick up the signal from a hearing loop and will drive a pair of headphones. You can use it with a hearing loop you install in your own home or with commercial loops already installed in halls and churches.

HEARING LOOP RECEIVER

By JOHN CLARKE

Elsewhere in this issue we introduce the concept of hearing loops for those with hearing loss. They're specifically intended for use with hearing aids fitted with T-coils (the other article explains T-coils).

But there are many people in the community who have hearing loss and, for various reasons (cost, denial and vanity are the main ones!) don't own or want a hearing aid, particularly one of the more advanced types.

This project, in fact this whole series of related projects, is intended for them – and anyone else who "suffers in silence" (or perhaps suffers in muffles!).

You might have experienced it in your own household: someone who wants the TV or stereo turned up beyond everyone else's comfort level so they can hear it.

Connect a hearing loop to your TV or stereo system, use this Hearing Loop Receiver and an earbud or two – and they will be able to hear everything in the program, with no need to have the volume cranked up!

Our Hearing Loop Receiver

It's housed in a small case which can attach to a belt or slip into a pocket, so it's fully self-contained. The user can walk around without the sudden jolt of reaching the end of a headphone lead! It's equipped with a power switch, power on LED, volume control and of course a standard 3.5mm jack outlet for headphones or earphones.

Current consumption is about 10mA, which should

Specifications

Current Consumption	10mA
Frequency response	-3dB at 100Hz with stereo 32Ω headphones connected. Upper response to beyond 5kHz
Signal to noise ratio (with a stereo 32Ω headphone connected)	-67dB A-weighted with respect to a 400mA/m field strength and VR1 at mid setting. Noise is dependent upon background environmental noise from mains wiring and equipment
Battery voltage indication	Down to 7V

give up to 40 hours of use before the 9V battery needs to be changed (a rechargeable battery could be used). The power LED also functions as a battery indicator where its initial brightness when power is applied is dependent upon battery voltage.

By now, we hope you've read the article in this issue on the design and installation of a hearing loop. That will give you a much better understanding of how the Hearing Loop Receiver works, so we won't go into a lot of detail here.

But if you haven't seen that article, a hearing loop at its most basic simply consists of a loop of wire around a room, driven by a standard audio amplifier. The magnetic field it produces induces the audio signal into a coil in a hearing aid equipped with a T-Coil or in this case, our Hearing Loop Receiver.

Circuit description

The circuit for the Hearing Loop Receiver is shown in Fig.1. It comprises two low-cost ICs plus a handful of other low-cost parts.

The magnetic field from the hearing loop is detected using inductor L1. This is actually the secondary winding of a standard Xenon flash tube trigger transformer (eg, Jaycar MM2520). Because of the very large number of turns, it has a high inductance – around 8.2mH. Best of all, it is quite cheap and is suitable for the task of hearing loop monitoring.

One side of L1 is biased at about +4.05V using two 10kΩ resistors connected in series across the 8.1V supply. A 100µF capacitor bypasses this half-supply. The 4.05V rail biases the output of IC1b so that its output can swing symmetrically within the available power supply rail.

Tying one side of the transformer secondary winding to the +4.05V supply means that it is effectively grounded while the other end of the winding provides the signal to op amp IC1b. The DC resistance of inductor L1 is 27Ω, presenting a low source impedance at low frequencies to the non-inverting input of IC1b and thereby minimising low-frequency noise.

A 2.2kΩ resistor is connected in parallel with L1 to lower the inductor's Q and prevent the possibility of oscillation. The 220pF capacitor that shunts high frequency signals to ground also assists in this. Furthermore, the input of each amp stage has a 10Ω "stopper" resistor to help prevent oscillation.

It's all housed inside a "remote control" case which is small enough to fit into a pocket, or clip to a belt via an optional clip. So if Grandpa forgets he's wearing it and gets up to walk around, he won't leave his head back in his easy chair!

Any signal induced in L1 will rise in level with frequency, at about 6dB per octave, because the induced voltage is proportional to the rate of change of the magnetic field.

To compensate for this and to provide a flat frequency response, a 33nF capacitor across the 100kΩ feedback resistor, between pins 6 & 7 of IC1b, rolls off signal above about 50Hz at 6dB/octave. This counteracts the rise in response from the inductor. At the same time, the frequency response is rolled off below 16Hz using the series connected 1kΩ resistor and 10µF capacitor between pin 6 and ground.

Op amp IC1a provides the second stage of gain, adjustable via the 10kΩ trimpot, VR1. In the trimpot's minimum position, the maximum gain is 101, as set by the 100kΩ and 1kΩ resistors. Minimum gain of about 10 is available when VR1 is set at maximum. Because of VR1, the low frequency rolloff at maximum gain is 16Hz (the same as for IC1b) and 1.45Hz at minimum gain.

Further frequency rolloff is provided by the 330pF capacitor across the 100kΩ feedback resistor. This rolls

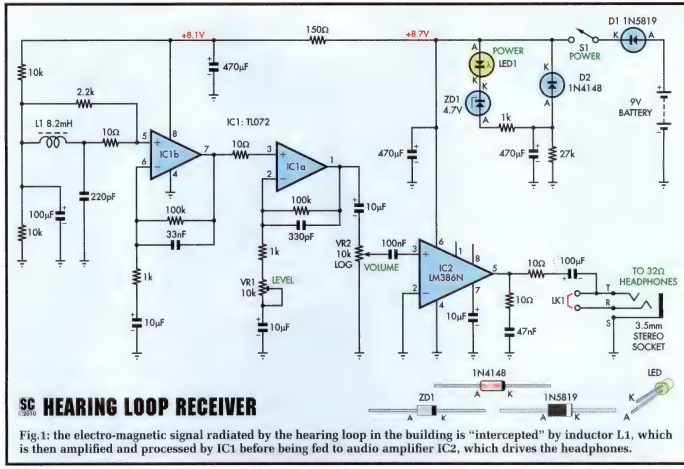

Fig.1: the electro-magnetic signal radiated by the hearing loop in the building is "intercepted" by inductor L1, which is then amplified and processed by IC1 before being fed to audio amplifier IC2, which drives the headphones.

off signals above about 4.8kHz.

Next, the signal passes through a 10µF coupling capacitor to the 10kΩ volume control, VR2. This sets the level the of signal applied to the LM386 audio power amplifier, IC2. This can provide up to about 500mW into 8Ω with a 9V supply, with distortion typically 0.2%.

When using stereo 32Ω headphones, the power is about 250mW; more than adequate for headphone listening.

Note that both left and right headphones are connected in parallel, via link LK1.

IC2 has a gain of 20 and its power supply is bypassed with a 470µF capacitor. The separate 10µF bypass at pin 7 removes supply ripple from the amplifier's input stages. A Zobel network comprising a series 10Ω resistor and 47nF capacitor prevents amplifier instability.

The LM386 drives the headphones via a 10Ω resistor and 100µF capacitor. The 100µF capacitor provides low frequency rolloff below 61Hz, assuming that 32Ω stereo headphones are used.

The circuit is powered by a 9V battery, while diode D1 provides protection against reverse polarity connection (which is quite easy to do with a 9V battery).

Controls are simple: just a power switch and volume. Most 3.5mm phones/ear buds will be fine. The large "block" at the back of the case is an optional belt clip so the unit can easily be worn around.

LED battery condition indicator

LED1 functions as a battery condition indicator, as well as showing when the Receiver is on.

When power is first applied, current for the LED flows through the 4.7V zener diode ZD1, the 1kΩ resistor and the discharged 470µF capacitor.

If the battery is fresh, the 9V battery provides 8.7V at the anode of LED1. This voltage is reduced by about 1.8V by LED1 and by 4.7V with ZD1, leaving 2.2V across the 1kΩ resistor. So LED1 lights with a current of 2.2mA.

At lower battery voltages, there is less voltage across the 1kΩ resistor so the LED is dimmer. At a battery voltage of 7V, there is about 0.2V across the 1kΩ resistor and the LED barely lights.

With LED current flow, the 470µF capacitor charges up so that the LED current is reduced. A 27kΩ resistor across the 470µF capacitor ensures that the LED stays lit but at a low current that allows it to be still visible. This indicates that the power is on and means that battery voltage testing happens only at power up. When the receiver is switched off, diode D2 discharges the 470µF capacitor.

The 8.7V supply is used directly by IC2 but it is fed to IC1 via a 150Ω resistor. A 470µF capacitor decouples this supply and prevents any supply modulation from affecting

IC1, which could cause instability.

Construction

The Hearing Loop Receiver is constructed on a PC board coded 01209101 and measuring 65 x 86mm. The PC board and components are housed in a "remote control" case measuring 135 x 70 x 24mm. Panel labels attach to the front edge of the box and on the front face.

The PC board is designed to fit onto the mounting bushes within the box. Make sure the front edge of the PC board is shaped to the correct outline so it fits into the box. It can be filed to shape if necessary using the PC board outline shape as a guide.

This PC board can also be used to build the Hearing Loop Neck Loop Coupler (which we will describe in a future issue) since most of the parts are the same. However, there will be a few unused component holes in the PC board for the Hearing Loop Receiver.

Begin construction by checking the PC board for breaks in tracks or shorts between tracks and pads. Repair if necessary. Check the hole size for the PC board mounting and for the 9V battery leads. These are 3mm in diameter.

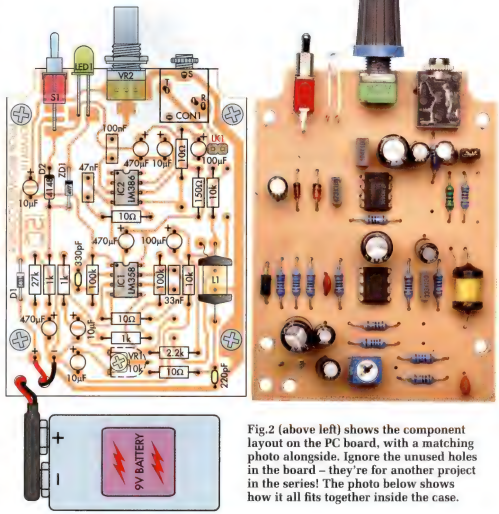

Fig.2 (above left) shows the component layout on the PC board, with a matching photo alongside. Ignore the unused holes in the board – they're for another project in the series! The photo below shows how it all fits together inside the case.

Assembly can begin by soldering in the two PC stakes, followed by the resistors. Use the resistor colour code table and/or a digital multimeter to help in confirming the resistor values. The diodes can now be installed, mounted with the orientation as shown.

IC1 & IC2 can be now be installed, either directly on the PC board or mounted on DIP8 sockets (which makes removal easier if necessary). When installing sockets or ICs, orient them using the notch positioned as shown.

Install the 2-way header (LK1), followed by the capacitors. Make sure the capacitors are placed on the PC board so their height above the board is no more than 12.5mm, otherwise the lid of the case will not fit correctly. Electrolytic types must be oriented with the shown polarity.

Trimpot VR1 and inductor L1 are next. Note the third wire of L1 is soldered to a spare pad on the PC board. Switch S1, potentiometer VR2 and the 3.5mm stereo socket can be soldered in next.

LED1 mounts horizontally but at a height of 6mm above the PC board. Bend its leads down 90°, 12mm from the base of the LED, making sure the anode lead is to the left.

To install the 9V battery clip, firstly pass the wires through from the battery compartment side of the case and loop the wires through the holes in the PC board. This secures the wires ready to be soldered to the PC stakes.

Four 6mm M3 screws secure the PC board to the integral mounting bushes in the box. However, before fitting, you will need to drill out the small holes for the switch, LED,

Fig.3 (right) the front panel label, reproduced here same size, depicts the Hearing Loop symbol. Itself adapted from the international "hearing assistance" symbol (with the added "T"), it is displayed wherever a hearing loop is installed. In many cases, there will also be raised Braille dots giving the same message to blind people.
Fig.4 (below) is the label which is glued to the top panel.

volume pot and headphone socket in the top panel. A 1:1 photocopy of the label makes a good template for drill hole positions.

Panel labels for this project can be downloaded from the Silicon Chip website (www.siliconchip.com.au). Go to the downloads section and select the month and year of publication.

The file can be printed out using stationery suitable for your printer. Some choices would be adhesive-backed photo paper, ordinary bond paper which could be laminated and glued onto the panel, or perhaps plastic film such as overhead projector film. If you use the latter, print the label as a mirror-image so that the ink is behind the film when placed onto the panel (that protects the label). Once the ink is dry, cut the label to size.

The plastic film can be glued to the panel using an even smear of neutral-cure silicone. If you are using a black coloured panel, use coloured silicone such as grey or white so the label has contrast. For panels that are off white or aluminium the silicone sealant can be clear.

Cut the holes out in the panel using a sharp hobby knife.

Testing

Apply power and check that the power LED lights. There should be about 8.1V between pins 4 and 8 of IC1 (assuming a 9V battery supply). IC2 should have about 8.7V between pins 4 and 6.

If these tests are OK, plug in a pair of headphones and apply the "blurt" test: touch the inductor (L1) terminal on the lower section of the PC board. There should be a "blurt" noise in the headphones if the volume is turned up.

Final testing can be made with the Hearing Loop Receiver and a Hearing Loop. Note that the receiver needs to be at right angles to the loop, ie, for a normal horizontally mounted loop, the receiver is held vertical. Trimpot VR1 is adjusted so that the volume range for VR2 is suitable without allowing the volume level to be adjusted to excessive levels.

If you require a belt clip for the receiver, the Altronics H0349 belt clip is suitable (www.altronics.com.au). SC

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	4	10Ω	brown black black brown	brown black black gold brown

Parts List – Hearing Loop Receiver

1 "remote control" case 135 x 70 x 24mm (Jaycar HB5610, Altronics H0343 or equivalent)
1 PC board coded 01209101, 65 x 86mm
1 top panel label 55 x 14mm
1 front panel label 75 x 49mm
1 miniature SPDT toggle switch, PC mount (S1)
1 3.5mm stereo socket, PC mount
1 knob to suit potentiometer
2 DIP8 IC sockets (optional)
1 trigger transformer for Xenon flashtube (L1) (Jaycar MM2520, Altronics M0104 or equivalent)
4 M3 x 6mm screws
1 2-way pin header with 2.54mm spacing
1 jumper shunt
1 9V (216) alkaline battery
1 9V battery clip
2 PC stakes

Semiconductors

1 TL072 dual op amp (IC1)
1 LM386 1W amplifier (IC2)
1 4.7V 1W zener diode (ZD1)
1 3mm LED (LED1)
1 1N5819 1A Schottky diode (D1)
1 1N4148 switching diode (D2)

Capacitors

3 470µF 16V PC electrolytic
2 100µF 16V PC electrolytic
4 10µF 16V PC electrolytic
1 100nF MKT polyester
1 47nF MKT polyester
1 33nF MKT polyester
1 330pF ceramic
1 220pF ceramic

Resistors (0.25W, 1%)

2 100kΩ 1 27kΩ 2 10kΩ
1 2.2kΩ 3 1kΩ 1 150Ω
4 10Ω
1 10kΩ horizontal trimpot (VR1)
1 10kΩ log potentiometer, 9mm square, PC mount (VR2)

Capacitor Codes

Value	µF value	IEC Code	EIA Code
100nF	0.1uF	104	100n
47nF	0.047uF	473	47n
33nF	0.033uF	333	33n
330pF	-	330	330p
220pF	-	220	220p

Charlieplexing

What it is & how it works

"Charlieplexing" is a multiplexing technique for driving displays and is particularly suited for use with microcontrollers. It reduces the number of outputs required to drive a given display but implementing it can be a little tricky. Here is an in-depth explanation of how it works.

By NICHOLAS VINEN

THE REMOTE-CONTROLLED Digital Up/Down Timer described in August 2010 features six 20mm-high LED digits in three dual displays. These are great because they are bright and easy to read from a distance but unlike a Liquid Crystal Display (LCD), they do not have an on-board controller IC. This means that driving them normally involves using external components and quite a few tracks on the PC board.

However, we found a way to drive all six digits using just nine tracks and no external components (apart from the microcontroller). The method we used is known as "Charlieplexing". It was originally developed by Christopher Malinowski in 1979 but was popularised by Charlie Allen at Maxim, with the development of the MAX6950 and MAX6951 ICs. These can drive five or eight 7-segment displays from a 16-pin IC package.

We used a similar scheme for our timer project, with a microcontroller in place of the specialised IC. This also allowed us to optimise the track connections, dramatically simplifying the board layout.

Multiplexing

Before describing how the technique works, let's first look at how a 7-segment LED display is normally driven. This method is not restricted to this type of display – it can be used with vacuum fluorescent displays, incandescent displays, Nixie tubes etc. The

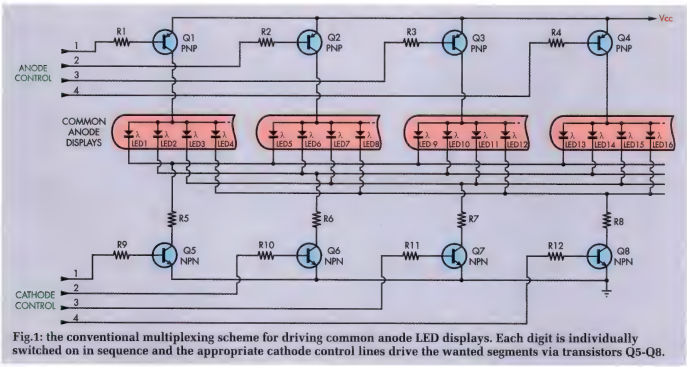

Fig.1: the conventional multiplexing scheme for driving common anode LED displays. Each digit is individually switched on in sequence and the appropriate cathode control lines drive the wanted segments via transistors Q5-Q8.

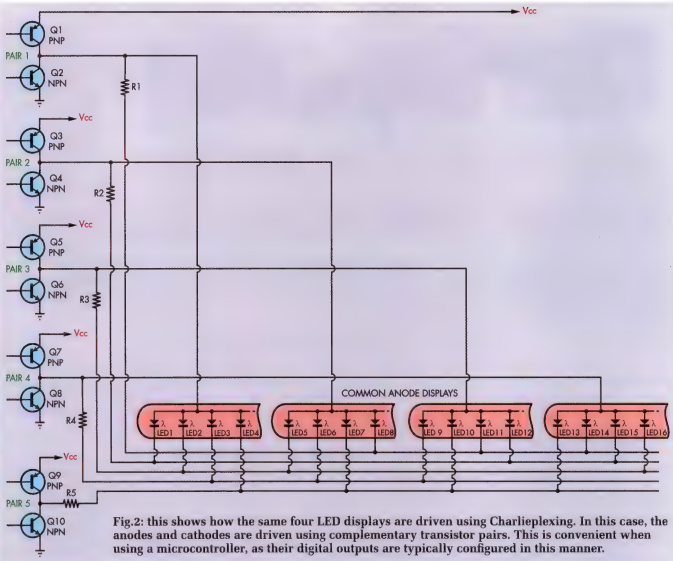

Fig.2: this shows how the same four LED displays are driven using Charlieplexing. In this case, the anodes and cathodes are driven using complementary transistor pairs. This is convenient when using a microcontroller, as their digital outputs are typically configured in this manner.

main differences are the drive voltage and current.

Fig.1 shows the conventional multiplexing arrangement, although we have simplified it by showing just four LEDs in each display and only four displays. However, this method can handle any number of segments or displays by adding more transistors and control lines.

Of course, as the number increases, routing the tracks becomes more difficult.

It works as follows: the anode control lines are active-low and only one of them is active at any given time. Typically, transistors Q1-Q4 are turned on in sequence with a 25% duty cycle. Conversely, the cathode control lines are active-high and any combination may be turned on at any given time.

Let's say we want to light LEDs 2, 4, 5 & 9. First, anode control line 1 is brought low and Q1 is turned on. At the same time, cathode control lines 2 & 4 are switched high. As a result, LEDs 1-4 are driven at the anode but only LEDs 2 & 4 are driven at their cathodes, so only these two LEDs light.

Before Q1 is turned off again, all the cathode control lines are brought low (off). Q2 then switches on and cathode control line 1 is switched high. In this case, LED5-8 are driven at their anodes but only LED5 is driven at its cathode and so only LED5 lights.

Finally, LED9 is switched on by turning Q3 on (after Q2 is turned off) and taking cathode control line 1 high. All the cathode control lines (and thus the cathode drivers) then remain off while Q4 is turned on, so that no further LEDs light.

Duty cycle

In this circuit, any LED can only be on 25% of the time because the driver transistors are switched in sequence. So in reality, when multiplexed LEDs are alight, they are actually flashing. However, by making them flash rapidly enough, they appear to be lit continuously due to persistence of vision (ie, our eyes cannot react rapidly enough to detect the flashing). As a result, we just see the lit segments.

It also follows that the LEDs are 25% as bright as they would be if switched on permanently, assuming equal currents. In practice, this is compensated for by using brighter LEDs or by driving them at higher peak currents. Most LEDs can handle much higher currents for brief periods than they can on a continuous basis (ie, at DC), as the ultimate limit is their dissipation rating. If they are only switched on a portion of the time, the average dissipation is a fraction of the instantaneous dissipation (in this case, 25%).

This multiplexing scheme is widely used and it works well but it has dis-

advantages. The main problem is the number of control lines necessary. It is the sum of the number of segments and the number of digits.

For last month's Digital Timer with six 7-segment digits (which have eight LEDs each, including the decimal point), this would mean 6 + 8 = 14 control lines. It would also require 14 transistors and 22 resistors.

This could be reduced by driving the cathodes directly from the microcontroller outputs but if this is done, it's difficult to make the segment brightness consistent between digits due to internal resistances in the microcontroller's power supply.

By using Charlieplexing, we managed to drive the displays using nine pins and no additional components.

Charlieplexing

Now take a look at the "Charlieplexing" arrangement shown in Fig.2. This shows the same LED displays as before but with the new driving arrangement. There are actually more transistors, five PNP and five NPN, but they are arranged as complementary pairs. This is handy because microcontroller digital outputs have a similar configuration.

If the transistors in a complementary pair are individually controlled, as they are in a micro, we have what is known as a "Tri-state" output (a term coined by National Semiconductor). If one transistor is on and the other is off, then the output is either active high or active low (ie, pull-up or pull-down). If both transistors are off, then the output is "high-impedance", ie, not driven. Switching both transistors on creates a short circuit between the supply rails so this condition is prevented.

Transistor pairs 1-4 drive one common anode and between one and four cathodes. It doesn't matter which cathodes are driven by which pair. However, the common anode of each display is driven by a different pair than for its cathodes.

As before, one anode is brought high at any given time. Transistor Q1 drives the first display's common anode, Q3 the second, and so on. When Q1 is switched on, the first display's four cathodes are controlled by Q4, Q6, Q8 & Q10. Similarly, when Q3 is switched on, the second display's four cathodes are controlled by Q6, Q8, Q10 & Q2.

Now, say we want to turn on the same LEDs as in our last example (ie, LEDs 2, 4, 5 & 9). We set pair 1 to active high, pairs 2 and 4 to active low and pair 3 to high impedance. That means that transistors Q1, Q4 and Q8 will be switched on while the rest will remain off. As a result, LED2 and LED4 will both be forward biased so they will light up.

Now consider LED8 in this state. It is also being driven at both ends – its anode by Q4 and its cathode by Q1. However because its anode is pulled low and its cathode high, it is reverse biased. Since LEDs act as diodes, no current will flow and so LED8 will remain off. This is the trick which allows Charlieplexing to control the same number of display segments with less control lines.

As before, to light the other segments, the microcontroller cycles through the anodes and turns on the appropriate cathodes.

In the case of the MAX6590/1 ICs, not only are the transistor pairs internal to the IC but the cathode transistors have an adjustable current limit, so no additional parts are required. You just need the IC, the four digits and five tracks. Since the order of the anodes and cathodes are not important, they can be re-mapped in the software – we can route those five tracks whichever way is most convenient.

As demonstrated in last month's timer project, similar results can be obtained with a microcontroller. The catch is that driving the display requires a fair bit of processing power as it is necessary to cycle through the segments one at a time and light them (or not) individually. This is because we must rely on the internal resistance in their output transistors to limit the current without additional resistors.

It is possible to add one resistor per cathode set to the circuit to solve this problem although brightness matching between digits can then become an issue, depending on the current at which the segments are being driven. However, either technique is valid and can provide simpler circuitry than the traditional multiplexing method.

Because Charlieplexing is software intensive, it is best suited to applications where the microcontroller does not have a lot of work to do besides driving the display. This is the case with our Digital Up/Down Timer and there are many other applications which can take advantage of "Charlieplexing" to simplify circuit design and PC board layout. SC

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Electrolytic capacitor reformer and tester

Last month we introduced our new electrolytic capacitor reformer and tester – ideal for anyone working with vintage radios, valve equipment or indeed the hobbyist who has gathered a collection of electrolytics over the years. Now you can not only test them, you can (usually!) breathe new life into them if they've suffered from the ravages of time!

Part 2: by JIM ROWE

With the exception of the power supply, microswitch (S6) and of course the capacitor under test/reforming, virtually all of the circuitry and components used in the Electrolytic Capacitor Reformer and Leakage Meter are mounted on a single PC board measuring 222 x 120mm and coded 04108101.

This is supported behind the transparent lid of the case – in fact, a modified storage organiser – which houses the instrument.

As you can see from the photos and assembly diagrams, the main board is suspended from the lid of the enclosure and label (which becomes the instrument's front panel) via four 25mm long M3 tapped spacers.

The LCD display module mounts just above the centre of the main board on four 12mm long M3 tapped Nylon spacers (or two such spacers if you use the Altronics LCD module).

The DC/DC converter's step-up transformer T1 (wound on a 26mm ferrite pot core) mounts on the main board at upper left using a 25mm long M3 Nylon screw and nut, while voltage selector switch S1 also mounts directly on the board at lower left.

The only components not mounted directly on the main board are power switch S2, pushbutton switches S3-S5, the two test leads (fitted with alligator clips) and, as mentioned earlier, the microswitch. All switches are mounted on the front panel, with their rear connection lugs extended down via short lengths of tinned copper wire to make their connections to the board. All of these assembly details should be fairly clear from the diagrams and photos.

To begin fitting the components on the main board we suggest you fit the fixed resistors. These are all 1% tolerance metal film components, apart from the 0.27Ω, 2.2kΩ and 8.2kΩ 5W resistors and the 2 x 1kΩ 1W resistors.

When you are fitting all of the resistors make sure you place each value in its correct position(s), as any mixups may have a serious effect on the meter's operation and/or accuracy. Check each resistor's value with a DMM if you want to make sure of no mistakes.

It's also a good idea to fit the 1W and 5W resistors with their bodies about 2mm above the top of the board, rather than resting on it. That's because these resistors can become quite warm during an extended 'electro reforming' test run.

It's logical to follow with the wire links, most of which are 0.4mm long, so they're easily fashioned from resistor lead offcuts. There are quite a few of these links, of which five are located underneath the position where the LCD module is fitted later.

Next place the eleven 1mm terminal pins in the board – two for each of the three test point locations, two for the DC input connection and three for the high voltage output (to the micro-switch and capacitor). Follow these with the sockets for IC1 and IC2 (both 8-pin sockets) and IC3 (an 18-pin socket).

After these are in place you can fit 25-turn trimpot VR1 at centre left and trimpots VR2 and VR3 at upper right. Next are the small low-value capacitors, followed by the two larger 470nF/630V metallised polyester units and finally the two high voltage elec-

WARNING: SHOCK HAZARD!

Because the voltage source in this instrument can be set to provide quite high DC voltages (up to 630V) and can also supply significant current (tens of milliamps), it does represent a potential hazard in terms of electric shock. We have taken a great deal of care to ensure that this hazard is virtually zero if the instrument is used in the correct way – ie, with the lid closed and secured – even to the extent of quickly discharging any capacitor when the lid is opened.

However, if the safely switching is bypassed, especially when it's set to one of the higher test voltages, it is capable of giving you a very nasty 'bite' should you become connected across the test clips or a charged high voltage capacitor. There are some situations where such a shock could potentially be lethal.

Do NOT bypass the safety features included in this design. We don't want to lose any Silicon Chip readers to electrocution.

The completed reformer and tester built into its modified "storage organiser" case. The circuitry, including the test clips, is completely isolated when the lid is closed and any charge on the capacitor under test/reforming is bled away safely when the lid is opened. There is plenty of room inside the case for the 12V DC power supply and in this case its IEC lead, which in use emerges from a hole cut in the side of the case alongside the supply.

trolytics, which lie on their side at the top of the board with their leads bent down by 90°. They are each held down using a Nylon cable tie which goes through the hole in the PC board and around the edge. Once the high voltage electros are in place you can mount the low voltage electros, three of which go at far right and the remaining 47µF unit at lower centre just near TP2.

Don't forget to fit all of the electros with their orientation as shown in the PC board overlay diagram (Fig.3), as they are all polarised.

Next fit the two relays, making sure that they too are orientated as shown in Fig.3. Then you can solder in voltage selector switch S1, which as you can see mounts with its indexing spigot in the '1:30' position. Before you fit the switch you should cut its spindle to a length of about 12mm and file off any burrs, so it's ready to accept its knob.

After switch S1 has been fitted to the board, remove its main nut/lockwasher/position stopwasher combination and turn the spindle by hand to make sure it's at the fully anti-clockwise limit. Then refit the position stopwasher, making sure that its stop pin goes down into the hole after the moulded '11' digits.

Next refit the lockwasher and nut to hold it down securely, allowing you to check that the switch is now 'programmed' for the correct eleven positions – simply by clicking it around through them by hand. You'll probably need to temporarily attach the knob first to get enough grip to turn it. If all is OK, remove the knob for now.

The next step is to wind the step-up autotransformer T1. This might sound a bit daunting, but it's not. You can find step-by-step instructions in the box titled 'Winding Transformer T1', which also explains how to fit the completed transformer to the main PC board.

The final components

With the transformer wound and fitted to the board, you'll be ready to install diodes D1-D6. These are all polarised, so make sure you orientate each one correctly as shown in Fig.3. Also ensure that D1-D3 are the three 1N4148 diodes, D4 is the UF4007 and the two 1N4004 diodes for D5 and D6. When fitting the two zener diodes ZD1 and ZD2, note that they are NOT the same voltage – and of course they too are polarised.

After the diodes install transistors Q1, Q2, Q4 and Q5, which are all TO-92 devices. Make sure that you fit the two BC337 (NPN) devices as Q1 and Q4, with the BC327 (PNP) devices as Q2 and Q5. You can follow these with voltage reference IC4, which is also in a TO-92 package. If in doubt, use a magnifying glass to confirm the type numbers.

Next come REG1 and Q3, which are both in TO-220 packages. In this project they each lie flat on the top of the board with a 19mm-square (6073B type) heatsink underneath and with their leads bent down by 90 degrees at a point about 6mm away from the body. Each device is then held in position on the board using a 6mm long M3 machine screw and nut. These should be tightened before the leads are soldered to the pads underneath to prevent stress on the pads.

Next fit LED1 to the board. It is located just to the right of the socket for IC1, with its cathode 'flat' side towards rotary switch S1. Note that it is fitted vertically, with its leads left almost at their full length – so that the bottom of the LED's body is about 22mm above the top of the board. This should mean that the top of the LED's body will just protrude from the matching hole in the case lid, after final assembly.

The final component to be mounted directly on the board is the connector for whichever LCD module you are going to use. In the case of the Jaycar QP-5516 module, this will be a 14-way (7x2) length of DIL (dual inline) socket strip, fitted vertically at the left-hand end of the module position; whereas if you are using the Altronics Z-7013 module, you will need to fit a 16-way length of SIL socket strip horizontally, along the lower long side.

Once this connector has been fitted and its pins soldered to the pads underneath, you'll be almost ready to mount the LCD module itself.

All that will remain before this can be done is to attach to the board either four or two 12mm long M3 tapped Nylon spacers, in the module mounting positions. This will mean two at each end in the case of the QP-5516 module, or only one at each end in the case of

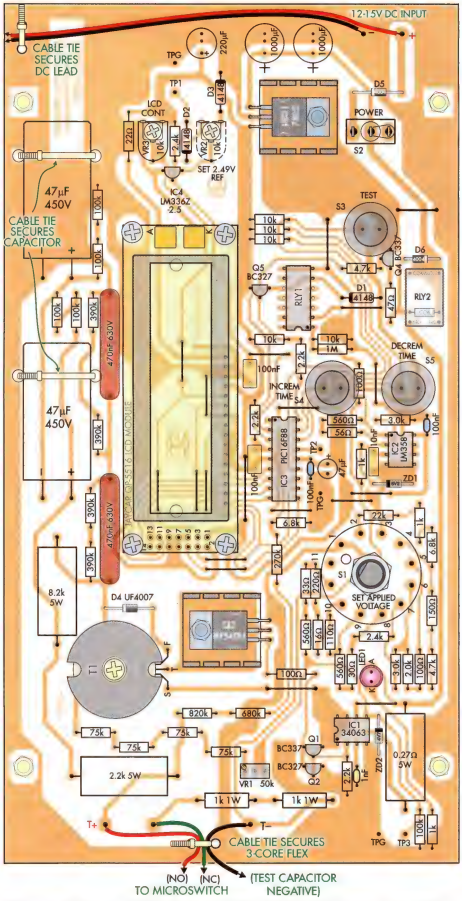


Fig.3: Apart from the 12V plugpack, interlock microswitch and test leads/clips, everything mounts on or is attached to the one large PC board, as shown here. The cable ties reduce the flexing on the soldered joints as the case is opened.

the Z-7013 module. In each case attach the spacers using a 6mm M3 screw passing up through the board from underneath – but in the case of three of the four screws for the QP-5516 module, you'll need to fit an M3 Nylon flat washer under each screw head as these screws are unavoidably close to tracks under the board.

Next 'plug' a 7x2 length of DIL pin strip into the socket strip you have just fitted to the board for the QP-5516 module, or a 16-way length of SIL pin strip into the socket strip for the Z-7015 module. Make sure the longer ends of the pin strip pins are mating with the socket contacts, leaving the shorter ends uppermost to mate with the holes in the module.

Now remove the LCD module from its protective bag, taking care to hold it between the two ends so you don't touch the board copper. Lower it carefully onto the main board so the holes along its left-hand end (QP-5516) or along its lower front edge (Z-7015) mate with the pins of the pin strip, allowing the module to rest on the tops of the 12mm long nylon spacers.

Then you can fit either one or two more 6mm M3 screws to each end of the module, passing down through the slots in the module and mating with the spacers. When the screws are tightened (but not OVER tightened!) the module should be securely mounted in position.

The final step is then to use a fine-tipped soldering iron to carefully solder each of the 14 or 16 pins of the pin strip to the pads on the LCD module, to complete its interconnections.

After this is done you can plug the three main ICs into their respective sockets, making sure to orientate them all as shown in Fig.3.

Your PC board assembly should now be just about complete. Before finishing it off (ie, putting it in the case), we will run a few checks on it to make sure everything is according to Hoyle.

Checkout and setup

NOTE: the following checks MUST be done with S1 on a low voltage setting (say 35V or less). NEVER apply power to the unit with S1 on a higher voltage setting without the PC board fitted to the case and the safety interlock in place.

If you connect the 12V DC plugpack to the mains and then switch on the power using S2, a reassuring glow

Winding Transformer T1

Many constructors are put off projects which involve winding a transformer but in most cases, it's not too difficult a job and requires just a little care and attention to detail.

In the case of the Electrolytic Capacitor Reformer and Tester, step-up autotransformer T1 has only 90 turns of wire in all, with an initial primary winding of 10 turns of 0.8mm diameter enamelled copper wire followed by four 20-turn layers of 0.25mm diameter enamelled copper wire to form the secondary.

And as you can see from the coil assembly diagram (Fig.4, below), all five layers are wound on a small Nylon bobbin which fits inside a standard ferrite pot core (bobbins are sold to match the cores).

Here's the procedure: first you wind on the primary using 10 turns of the 0.8mm diameter enamelled copper wire primary, which you'll find will neatly take up the width of the bobbin providing you wind them closely and evenly. Then cover this first layer with a 9mm-wide strip of plastic insulating tape or 'gaffer' tape, to hold it down.

Now twist the start of the 0.25mm wire around the 'finish' end of the primary winding and proceed to wind on the first layer of the secondary – winding in the same direction as you wound the primary, of course.

In this case you should find that 20 turns will neatly take up the width of the bobbin, providing you again wind them closely and evenly.

After winding this first layer of the secondary, cover it with another layer of insulating tape. Then wind on another layer, again of 20 turns and cover it with a layer of insulating tape as before.

Exactly the same procedure is then followed to wind on the third and fourth layers of the secondary.

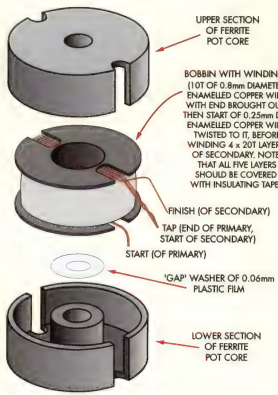
Each of these extra layers should be covered with another 9mm-wide strip of plastic insulating tape just as you did with the first layer, so that when all five layers have been wound and covered, everything will be nicely held in place.

The 'finish' end of the wire can then be brought out of the bobbin via one of the slots (on the same side as the primary start and primary finish/secondary start leads) and your wound transformer bobbin should be ready to fit inside the two halves of the ferrite pot core.

Just before you fit the bobbin inside the bottom half of the pot core, though, there's a small plastic washer to prepare. This is to provide a thin magnetic 'gap' in the pot core when it's assembled, to prevent the potcore from saturating when it's operating.

The washer is very easy to cut from a piece of the thin clear plastic that's used for packaging electronic components, like resistors and capacitors. This plastic is very close to 0.06mm thick, which is just what we need here.

So the idea is to punch a 3-4mm diameter hole in a piece of this plastic using a leather punch and then use a small pair of scissors to cut around the hole in a circle, with a diameter of 10mm. Your 'gap' washer will then be ready to place inside the lower half of the pot core, over the centre hole.



Once the gap washer is in position, you can lower the wound bobbin into the pot core around it and then fit the top half of the pot core. Your autotransformer should now be ready for mounting on the main PC board.

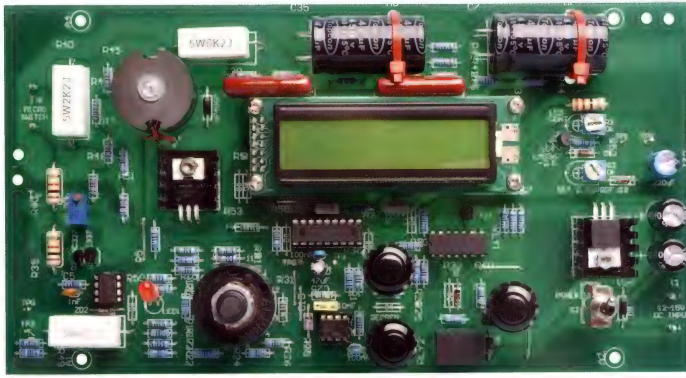
To begin this step, place a Nylon flat washer on the 25mm-long M3 Nylon screw that will be used to hold it down on the board. Then pass the screw down through the centre hole in the pot core halves, holding them (and the bobbin and gap washer inside) together with your fingers.

Then lower the complete assembly down on the upper left of the board with the 'leads' towards the bottom, using the bottom end of the centre Nylon screw to locate it in the correct position.

When you are aware that the end of the screw has passed through the hole in the PC board, keep holding it all together but up-end everything so you can apply the second M3 Nylon flat washer and M3 nut to the end of the screw, tightening the nut so that the pot core is not only held together but also secured to the top of the PC board.

Once this has been done, all that remains as far as the transformer is concerned is to cut the primary start, 'tap' (primary finish/secondary start) and secondary finish leads to a suitable length, scrape the enamel off their ends so they can be tinned and then pass the ends down through their matching holes in the board so they can be soldered to the appropriate pads.

Don't forget to scrape, tin and solder BOTH wires which form the 'tap' lead – if this isn't done, the transformer won't produce any output.



The finished PC board, ready for mounting in the case. While pushbutton switches S3, S4 and S5 are shown in position here for the photograph, they are normally not soldered in until the board is mounted on the front panel – they have to pass through the panel from above and are connected to the PC board via lengths of tinned copper wire.

should appear from the LCD display window – from the LCD module's backlighting. You may also be able to see the Meter's initial greeting 'screen'. If not though, you'll need to use a small screwdriver to adjust contrast trimpot VR3 until you get a clear and easily visible display. (VR3 is adjusted through the upper small hole just to the right of the LCD window.)

After a few seconds, the display should change to the Meter's measurement direction 'screen', where it tells you to set the appropriate test voltage (using S1) and also the test time period (using S4 and/or S5), before pressing the Start/Stop Voltage Application button (S3) to begin the test.

Note that if you make no adjustments to the test time period using S4 or S5, the default time period will be 10 seconds.

If you just set the test voltage and press S3 at this stage, without any capacitor connected to the alligator clips (make sure the alligator clips cannot short!), LED1 should begin glowing to indicate that the test voltage is being presented to the test terminals and the LCD display should change to read:

```
Vtest=ON  0m09s
Cap Lkg=  0.00µA
```

where the time displayed on the right end of the upper line will be decrementing to show the ON time remaining. Then when the remaining time falls to zero, you'll hear a soft 'click' and LED1 will go dark to indicate that the test voltage has been removed. At the same time the top line of the display will change to read:

```
Vtest=OFF  0m 0s
```

while the lower line will remain unchanged.

Assuming all has gone well at this point, your unit is probably working correctly. However if you want to set its calibration to ensure maximum accuracy of the readings, try connecting your DMM between the terminal pins TP1 and TPG (at upper right on the board, accessible via the gap between the board and front panel). You should get a reading of close to 2.5V and assuming this is the case try adjusting trimpot VR2 with a small screwdriver until you get a reading as close as possible to 2.490V.

Now set your DMM to a range where it can read a voltage of 63V accurately and connect its probes between the Meter's test terminals. Then turn S1 to the '63V' position and press S3 to turn on the test voltage source. The DMM reading should quickly rise to read very close to 63.0 volts and if so there's no need to go further. But if the reading is not within the range of 62.5 - 63.5V, you'll need to bring it inside this range (and ideally to 63.0V) using a small screwdriver or insulated alignment tool passed down through the hole in the front panel midway between the test terminals, to adjust the setting of VR1. Once you set the test voltage on the 63V range in this way, all of the other voltage settings will be correct as well.

Note that if you haven't set the Meter's timer to increase the testing time period from its default 10 seconds, the timer will turn off the test voltage after this time. So if you want to take your time to adjust the voltage to 63V using VR1, you might want to crank up the time period using S4, to keep the test voltage present for as long as you need.

Once the 2.49V reference voltage and the 63V test voltage have been set in this way, your Electrolytic Capacitor Reformer/Leakage Meter has been set up correctly and will be ready to be fitted into the case.

Preparing the "case"

As mentioned earlier, the case we

have used is a little unusual. It's sold as a "Storage Organiser" and is made by Trojan. Ours came from Bunnings Hardware for the princely sum of $9.95. It has a transparent hinged lid and in the "body" it has three rows of fixed dividers plus quite a number of movable dividers which fit into slots moulded into the fixed dividers.

First determine where your PC board will lie inside the case. Use an enlarged photocopy of the front panel (see Fig.7) or a same-size copy of the PC board layout and use it on the outside of the case as a template for drilling.

The left-to-right position is fairly unimportant (just make sure you leave enough room for the leakage current guide if you use the PC board layout diagram). However, you need to make sure that the PC board lies exactly in the space between the vertical dividers so that when the lid is closed, it fits!

There are four holes to be drilled to mount the PC board and nine for controls/indicators. You don't need to cut a slot for the LCD readout because the lid is transparent enough to read through it. (Yeah, we know, our photos show a cutout – we did that before we realised it was transparent enough! D'oh!) You will, however, need a cutout in the front panel label.

We modified the case to accommodate the PC board by removing a 30mm deep by 215mm long section from one of the fixed dividers, then cut notches along the moulded slots about 10mm wide and about 25mm down from the top. The photo of our modified case gives a better idea.

The PC board sits down in the removed divider section and along the slot notches each side. 25mm threaded standoffs then mount the PC board to the underside of the lid, onto which we had previously glued the front panel and drilled the required holes (actually we melted the holes with a fine soldering iron but don't tell the boss!).

You'll also need to mount the microswitch so that it is actuated when the lid is closed. The microswitch has two mounting holes through the body which make this fairly simple. It doesn't have to be horizontal when mounted, in fact a little bit an angle makes the action on the actuator arm more certain.

Holes also need to be drilled (or melted) through the divider walls to allow the HV wires (from PC board to microswitch/negative capacitor terminal) to pass through, along with the wires from the plugpack to the PC board.

Power supply

While we have built the prototype with a switch-mode 12V 2A plugpack, that's not the only option.

The supply can be virtually any 12-15V DC type with a minimum of about 1.5A output – just so long as it fits inside the case.

If you use a plugpack, it obviously needs to be outside the unit when in operation. Therefore a small slot can be cut in the outside vertical wall of the case, just deep enough to allow the figure-8 cable to pass through when the lid is closed and locked.

An alternative is to use a switch-mode adaptor supply – one we had on hand was a 12V, 4A type which came from Altronics (Cat M8938). At 60mm wide, this particular supply fits nicely into the case, as our photo shows.

Yet another, often much cheaper, alternative, is to use what is commonly sold as a "hard disk drive" supply – they're usually about the same size as the above model (or a little less), and have a 12V, 2A DC ouput (along with a 5V 2A ouput which can be ignored).

The latter supply is often sold with, or is available for, external hard disk drives and we've seen them advertised for less than $5 each!

Both of these supplies generally have an IEC socket so a standard IEC power cable can be used. To do this, a 30mm hole could be cut in the case side to allow the supply's IEC plug to fit through, which would then allow the supply to remain inside the case when in use.

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	1	820kΩ	grey red yellow brown	grey red black orange brown
❑	1	680kΩ	blue grey yellow brown	blue grey black orange brown
❑	4	390kΩ	orange white yellow brown	orange white black orange brown
❑	1	270kΩ	red violet yellow brown	red violet black orange brown
❑	5	100kΩ	brown black yellow brown	brown black black orange brown
❑	4	75kΩ	violet green orange brown	violet green black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	3.0kΩ	orange black red brown	orange black black brown brown
❑	2	2.4kΩ	red yellow red brown	red yellow black brown brown
❑	4	2.2kΩ	red red red brown	red red black brown brown
❑	1	2.0kΩ	red black red brown	red black black brown brown
❑	5#	1kΩ	brown black red brown	brown black black brown brown
❑	2	560Ω	green blue brown brown	green blue black black brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	1	110Ω	brown brown brown brown	brown brown black black brown
❑	3	100Ω	brown black brown brown	brown black black black brown
❑	1	56Ω	green blue black brown	green blue black gold brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	33Ω	orange orange black brown	orange orange black gold brown
❑	1	30Ω	orange black black brown	orange black black gold brown
❑	1	22Ω	red red black brown	red red black gold brown
❑	1	16Ω	brown blue black brown	brown blue black gold brown

(All 5W resistors will have values printed on them. # 2 1kΩ are 1W.)

Capacitor Codes

Value	µF value	IEC Code	EIA Code
470nF	0.47uF	474	470n
100nF	0.1uF	104	100n
10nF	0.01uF	103	10n
1nF	0.001uF	102	1n

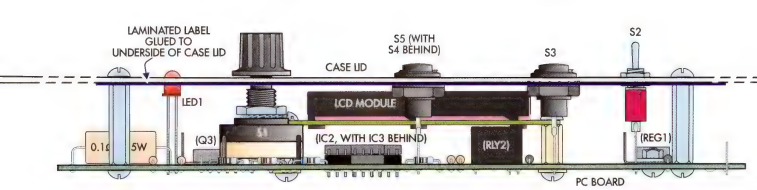


Fig.5: the PC board "hangs" from the case lid, which becomes the front panel. The label is on the inside of the lid.

There's even room to store an IEC cable inside the case in the area you would normally connect the capacitor under test/reforming.

We used the front 1/3 of the case for the capacitor under re-forming or test and storage for the supply. One of the supplied orange dividers makes neat separate compartments for both the capacitor and the supply.

Fitting the front panel

Before proceeding to final assembly, tinned copper extension wires need to be soldered to the three pushbutton switches (S3-S5) which will go through the front panel from above and soldered to the underside of the PC board when it is in position.

A tip here is to make all of the S3-S5 extension wires slightly different lengths and longer than you'd think necessary (say from 30 to 50mm) so that when one goes in, it doesn't pop out doing the next one!

Unfortunately, the front panel is longer than a SILICON CHIP page so we haven't been able to provide a same-size artwork as normal. The easiest way to get the panel is to download the PDF from siliconchip.com.au and print it. A colour printer is the best but you will need to be able to print A3 paper.

To provide a little more protection and rigidity, we laminated ours (again, an A3 laminator is required), cut out all the holes (including the LCD hole) then glued it, face-side up, inside the lid of the case using spray adhesive.

Hopefully all the holes you previously drilled in the panel will line up with those you drilled earlier.

Allow the glue to dry and you should now be ready for the only slightly fiddly part of the assembly operation: attaching the PC board assembly to the rear of the lid/front panel.

This is only fiddly because you have to line up all of the extension wires from switches S2-S5 with their matching holes in the PC board, while you bring the lid and board together and at the same time line up the body of LED1 along with switches S1 and S2 with their matching holes in the front panel.

Just take your time and the lid will soon be resting on the tops of the board mounting spacers. Make sure LED1 is poking through its hole, then you can secure the two together using the four remaining 6mm long M3 machine screws, with washers underneath the heads to protect the relatively soft plastic of the case lid.

Now it's a matter of soldering each of the switch extension wires to their board pads. Once they are all soldered you can clip off the excess wires with sidecutters.

Place the power switch washer and nut on the thread and tighten (adjust the underside nut up or down as necessary so you don't bow the plastic) and finally make sure the LED is poking through its front panel hole.

Final wiring

Power wiring (from the 12V power supply/plugpack) and high voltage wiring (to the microswitch and capacitor negative) can be attached to the PC stakes even with the board in position. It's a bit fiddly and you have to be careful not to damage the plastic lid but the stakes are close enough to the outer edges of the PC board to make this possible.

To protect the soldered joints, as much as possible, as the lid is opened and closed, we secured both the power supply and output cables to the PC board using small cable ties.

Remember to run the various wires through the holes you have drilled in the divider walls before soldering to the PC board. The power supply connections are straightforward (remember the polarity!) but the high voltage wiring is just a bit more difficult. Note our comments earlier about the type of cable used for the high voltage cable: it must be rated at 250V or higher.

- *The wire from the HV+ terminal goes to the microswitch "NO" terminal.*
- *The wire which connects to the 2 x 1kΩ 1W bleed resistors on the PC board goes to the microswitch "NC" terminal.*
- *The wire from the microswitch "COM" terminal goes direct to the capacitor positive (red) alligator clip.*
- *The wire from the T- terminal goes direct to the capacitor negative (black) alligator clip.*

By the way, if you find this description a bit confusing, refer to the diagrams of Figs. 3&5 and also the inside photos shown last month. These will hopefully make everything clear.

Using it

The new Electrolytic Capacitor Reformer is very easy to use, because literally all that you have to do is connect the capacitor you want to test between the alligator clips (with the correct polarity in the case of solid tantalums and electrolytics), close the lid, set selector switch S1 for the correct test voltage and then turn on the power using S2 (assuming you have already plugged in your plugpack supply).

When the initial greeting message on the LCD changes into the 'Set Volts & Test Time, Press Strt' message, press S4 and/or S5 to set the time period to whatever you need. Then it's simply a matter of pressing the Start/Stop Voltage Application button (S3) to start the test.

What you'll see first off may be a reading the capacitor's charging current, which can be almost 20mA at first (with high value caps) but should then drop back as charging continues.

How quickly it drops back will depend on the capacitor's value. With capacitors below about 4.7μF, the charging may be so fast that the

first reading you see may be less than 100µA, with the meter having immediately downranged.

If the capacitor you're testing is of the type having a 'no leakage' dielectric (such as metallised polyester, glass, ceramic or polystyrene), the current should quickly drop down to less than a microamp and then right down to zero. That's if the capacitor is in good condition, of course.

On the other hand if the capacitor is one with a tantalum or aluminium oxide dielectric with inevitable leakage, the current reading will drop more slowly as the test proceeds.

In fact it will probably take up to a minute to stabilise at a reasonably steady value in the case of a solid tantalum capacitor and as long as 3 minutes in the case of a 'good' aluminium electrolytic. (That's because these capacitors generally take a few minutes to 'reform'.)

As you can see from the guide table attached to the front panel, the leakage currents for tantalum and aluminium electrolytics also never drop down to zero but instead to a level of somewhere between about 1µA and 9200µA (ie, 9.2mA) depending on both their capacitance value and their rated working voltage.

So with these capacitors, you will need to set the Meter's testing time period to at least 3 minutes to see if the leakage current reading drops down to the 'acceptable' level as shown in the front panel table and preferably even lower.

If this happens the capacitor can be judged 'OK' but if the current never drops to anywhere near this level this indicates that it is in need of either reforming or replacement.

What about low leakage (LL) electrolytics?

Well, the current levels shown in the table are basically those for standard electrolytics rather than for those rated as low leakage.

So when you're testing one which is rated as low leakage, you'll need to make sure that its leakage current drops well below the maximum values shown in the guide table. Ideally it should drop down to no more than about 25% of these current values.

Another tip: when you're testing non-polarised (NP) or 'bipolar' electrolytics, these should be tested twice – once with them connected to the alligator clips one way around and then again with them connected with the opposite polarity.

That's because these capacitors are essentially two polarised capacitors internally connected in series back-to-back. If one of the dielectric layers is leaky but the other is OK, this will only show up in one of the two tests.

Reforming old electros

While reading the preceding paragraphs about testing capacitors, you've perhaps been wondering about the Reformer's main function: reforming electrolytics that may have high leakage currents due to a long period of inactivity.

How do you use it for this function? In exactly the same way as you use it for testing capacitors, except that for reforming you set the timer for a much longer testing time period.

The idea here is that you still set S1 for the capacitor's rated voltage but simply crank up the testing time period using S4 until it's set for either 30 or 60 minutes. Then connect the capacitor to the alligator clips (making sure of the polarity) and finally press the

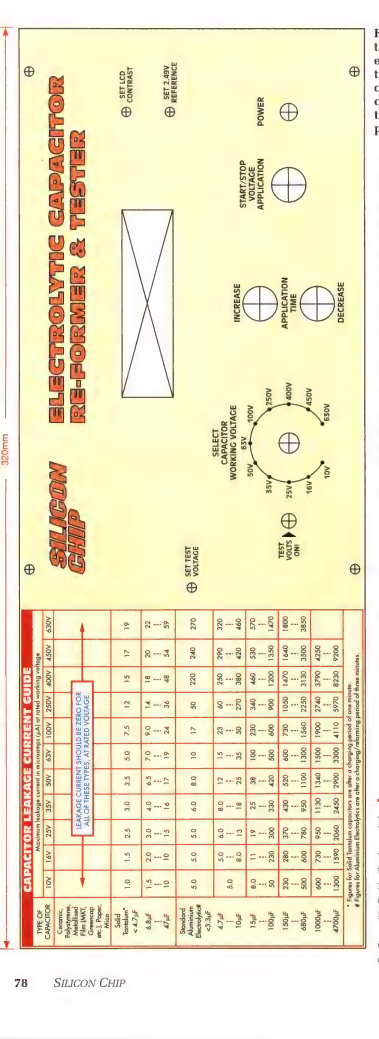


Fig.6: the front panel, which incorporates the leakage table, is too big to fit on the page, so is reproduced at exactly 75%. If you photocopy this at 133% (which in this case you can do without infringing copyright) it will come out right size. Obviously, you'll need a copier that can handle A3 paper. Alternatively, you can download the PDF file from siliconchip.au You'll still need a printer that can handle A3 paper!

Start/Stop Voltage Application button (S3) to start the test/reforming operation.

Because the metering part of the instrument will continue to make measurements during the reforming period, this allows you to keep track of the leakage current as it slowly falls from its initial high figure (which may well be up in the region of 20mA). This is due to the oxide dielectric inside the electro slowly regrowing (reforming) as a result of the current passing through it.

Needless to say if the current readings don't fall, even slowly, the electro concerned is beyond being reformed and should be scrapped.

On the other hand if the current readings do fall significantly but still don't come down to an acceptable level, this indicates that the electro will probably benefit from another reforming operation.

There's no problem about giving a capacitor repeated reforming operations, provided that it doesn't get overheated. In fact, significant heating is really a sign that the electro is beyond reforming and is not worth any further rescue efforts.

So this is the basic procedure, when dealing with electrolytics:

1. First give it a standard 3-minute test run at rated voltage and see if the leakage current tapers down to an acceptable level during this time. If it does, the capacitor is OK.
2. If the current doesn't taper down significantly and/or the capacitor becomes overheated, it is beyond help and should be discarded.
3. If the current does taper down significantly but doesn't reach an acceptably low level, it can be regarded as a candidate for reforming. Give it a test/reforming run of 30 or 60 minutes.
4. At the end of the reforming run, test it again with a standard 3-minute test period. If the leakage current is now in the acceptable range (according to the guide on the front panel), the capacitor has successfully reformed and is now OK. But if it hasn't quite finished reforming, it would be worth giving it another 30 or 60-minute session to see if this will 'do the trick'.

Errata

In the parts list published last month, no mention was made of the mains power adaptor. As discussed in this month's text, you'll need a 12-15V DC supply at a minimum of about 1.5A. A more robust supply (ie higher current output) won't hurt but it does need to be able to fit into the case!

Also, six (not two) small cable ties are needed, the extras to secure the cables from the PC board to the microswitch/test leads and 11, not 10 PC pins are required.

All you need to know about . . . electrolytics!

Most SILICON CHIP readers will be aware that all capacitors consist of two electrodes separated by an insulating dielectric.

It's the dielectric which allows the capacitor to store energy (ie, a 'charge') in an electric field between the two electrodes. The capacitance is directly proportional to the surface area of the electrodes on either side of the dielectric, and inversely proportional to the thickness of the dielectric itself. So to achieve a high capacitance the electrode area must be as large as possible, while the dielectric must be as thin as possible.

There's also another factor which determines the capacitance: the dielectric constant 'k' of the dielectric material. The capacitance is again directly proportional to this property, so to achieve a high capacitance you need to use a dielectric material with as high a k value as possible. Examples are polyester/Mylar with a k of 3.0 and mica with a k value of 6.0.

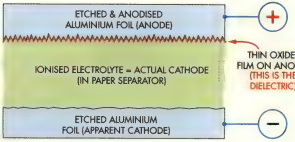
Electrolytic capacitors were developed about 90 years ago in an effort to produce high value capacitors which were at the same time much more compact than other types. Over the years they have been greatly improved but they are still not quite as reliable and they don't have the very low leakage of other capacitors such as mica, ceramic or polyester.

As you can see from the diagram of Fig.7 (above), both electrodes in an electrolytic capacitor are made from thin aluminium foil and between them is sandwiched a sheet of paper soaked in a conducting liquid or 'electrolyte' (often sodium borate in aqueous solution, with additives to retard evaporation).

So superficially it would seem that we have a pair of conducting electrodes separated not by an insulating dielectric but by a sheet of paper soaked in conductive electrolyte.

But before the capacitor is assembled, the aluminium foil which is to become the anode (positive electrode) has its surface etched in a caustic soda solution to greatly increase its surface area. This process covers the surface with an array of microscopic pits, which can have a total effective surface area of up to 60 times greater than the original unetched area for high voltage electrolytics and even higher for low voltage electros.

The etched aluminium foil is then subjected to an anodising process, whereby a very thin aluminium oxide layer covers the surfaces of all of the microscopic pits. This aluminium oxide is not only an insulating dielectric but it also has a relatively high k value of 8.5.



So electrolytics have large capacitance because of these three factors, the very high surface area of the anode, the very thin aluminium oxide dielectric and the relatively high dielectric constant of around 8.5.

The anodising process was originally referred to as "forming" as in forming the oxide layer.

The capacitor is wound with the etched/anodised foil, a paper separator and the non-anodised aluminium foil which becomes the negative electrode. The capacitor windings are usually then immersed in a bath of electrolyte and connected to a power supply to "re-form" the anodised layer on the positive foil which is inevitably damaged during the winding process.

After that, the windings have their terminations connected to an aluminium can in the case of the negative electrode and to the positive terminal for the anode. The can is sealed with a rubber bung and then it is reconnected to a power supply for a final re-form and leakage current test.

It should be noted that the electrolyte layer is critical to the performance of the capacitor. Because it is a liquid, it can fill the etched pits in the oxide layer. This means that the actual cathode is in intimate contact with the dielectric layer, minimising dielectric thickness and therefore maximising capacitance.

New electrolytic capacitors typically have a shelf life of many years but the older they get, the higher their leakage current becomes as the oxide layer on the aluminium anode gradually deteriorates, due to the lack of a polarising DC voltage. In most cases, though, such capacitors can be rejuvenated by a re-forming process whereby they are connected to a DC supply via a suitable current limiting resistor.

Initially, when the DC voltage is applied, the leakage current will be quite high but it should come down within a minute or so to a value which is less than the capacitor's specified leakage current at the rated voltage. This project makes that process easy and safe for electrolytic capacitors with a wide range of voltage ratings, in addition to measuring the capacitor's leakage current.

So that's what is inside an electrolytic capacitor and that is why it is able to provide a very high capacitance in a surprisingly small package. The main drawback of electrolytics is that they always exhibit at least a small leakage current — as shown in the front panel table. So they are really only suitable for use in circuits where this small leakage current does not upset circuit operation. Luckily this still gives them a great many applications.

SC

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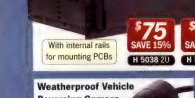

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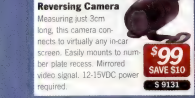

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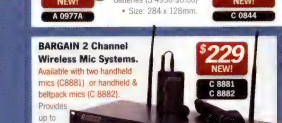

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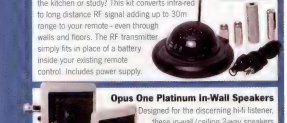

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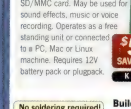
(SC June '09) Provides an adjustable 10Hz to 30kHz output in sine, square, triangle and sawtooth waveforms for testing amplifiers, speakers and other audio devices. Three output ranges: 20mV, 200mV & 1V. Requires 9V battery.

Only available at Altronics!



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Vintage Radio

By MAURIE FINDLAY, MIEAust., VK2PW

All about thermionic valves (or vacuum tubes) . . . as told by a veteran radio designer

Valves reigned supreme in the electronic world for more than 40 years, being the essential components of radio receivers, transmitters, early computers and many other devices. When television first came to Australia, it was black & white and the sets used valves. It has now been 50 years since the end of the valve era.

WITH AN EYE to preserving our history, there are many enthusiasts who restore early equipment, mostly radio receivers from the 1930s, 40s and 50s. Most popular sets used from four to six valves and many of them were well made and are well-worth keeping as representative of the technology of the era.

During the World War 2 (WW2), all radio communication depended on valves. It wasn't much use sending up a squadron of fighter planes if they couldn't talk to each other and coordinate the operation. Initially, valves were the least reliable parts in the equipment used until valve manufacturers in several countries made them much more rugged.

These military valves were produced using the latest technology available and in versions equivalent to ordinary valves. Most of them, if not abused, will meet their original specifications after 60 years.

Not all people restoring early radios will be trained technicians or engineers. They may be able to do a great job of polishing the cabinet, replacing the dial cord and even repairing the speaker cone. However, when switched on, the set just doesn't perform as well as it should. Maybe the maximum volume is limited or it will pull in only strong local stations. If so, does the set need realignment or does it have a faulty valve? Or could something else be wrong?

Valves are a common reason for poor performance in old radios and this article will answer some of the questions that are commonly raised by people restoring vintage sets.

But first a word of warning. Most enthusiasts will be aware of the basic safety issues for radios operating from the 230VAC power mains. If you are not confident about dealing with mains-operated equipment, then leave well alone. Even if you are capable and know what you are doing, be careful about doing repairs for acquaintances. There could be legal implications if something goes wrong.

We'll assume here that we are dealing only with sets that have a mains transformer. If you have such a set, it should be fitted with a good-quality 3-core power lead that's been properly anchored and has a good earth connection to chassis.

Unless you a very experienced and know exactly what you are do-

Taken in February 1954, this picture shows "Radio & Hobbies" staff members Raymond Howe, Neville Williams, John Moyle (Editor) and Maurice Findlay on the roof on "The Sun" newspaper building in Elizabeth St, Sydney (there to watch the Queen proceed down nearby Macquarie St during her 1954 visit to Australia). Both Raymond Howe & John Moyle served in the RAAF during WW2, specialising in signals and radar.

ing, don't touch transformerless (hot chassis) AC/DC sets that have one side of the mains (Active or Neutral) connected to chassis. They are absolute death traps for the unwary and should be avoided.

What sort of valves are there?

The simplest electronic valve type is the diode. It has two elements – the cathode and the plate (anode). When the plate is made positive with respect to the cathode, electrons are attracted to it and a current flows. Conversely, if the plate is negative with respect to the cathode, no current flows.

Diode valves are used to rectify alternating current. The larger diodes typically rectify the high-voltage AC secondary of the mains transformer, while the smaller diodes are used to recover the audio modulation from radio frequency (RF) signals. More often than not though, the latter will not be a single diode valve but will instead be incorporated into other valve types. In fact, there will usually be two diodes in the envelope – one to recover the audio and the other to derive the AGC (automatic gain control) signal.

The next valve on the list is the "triode". It has an element called a "grid" which is placed between the cathode and the plate. This grid usually consists of a fine helix of wire which surrounds the cathode.

In operation, the grid is usually made slightly negative with respect to the cathode and, depending on the voltage applied to it, controls the electron flow to the positive plate. In this way, it can be made to amplify.

As a result, triodes in radio receivers are usually used to amplify audio signals (ie, the audio is fed to grid of the triode stage). However, triodes have problems operating at radio frequencies (RF) because of the capacitance that exists between the plate and the grid (known as Miller Effect).

This problem can be overcome by placing another helix of wire around the control grid, to screen it from the plate. Valves with this feature are known as "tetrodes" and are used in simple circuits to amplify RF signals.

Another grid called the "suppressor" is often also placed around the screen grid. This improves the efficiency of the valve which is now called a "pentode". Like the screen grid, the suppressor grid also usually takes the form of a helix but the turns are more widely spaced.

A special case for power valves is the "beam tetrode". It employs a special construction technique that does away with the need for a suppressor. Pentodes are commonly used for both audio and RF amplification.

Special valves

To make things more complicated, there are a number of special valves that are frequently used in superheterodyne receivers to convert the tuned RF signal to the intermediate frequency (IF). One such valve is the "triode heptode"

In this type of valve, the triode element forms part of an oscillator and it injects the oscillator signal into a screened grid which is in the main electron stream to the plate. As a result, the intermediate (IF) signal appears at the plate and is then fed to the receiver's IF stages.

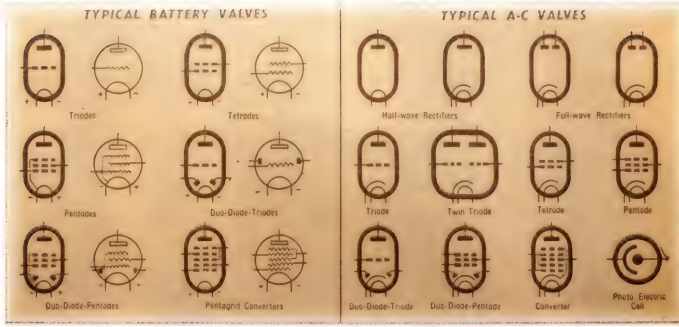


Fig.1: reproduced from the April 1949 issue of "Radio & Hobbies", this diagram shows the various valve types that were available. The valves designed for battery sets used directly-heated cathodes, while valves designed for use in mains-operated sets generally used indirectly-heated cathodes to eliminate hum problems.

Most valve superhet receivers use a triode-heptode for the input stage. However, more elaborate receivers may use a pentode RF amplifier stage before the frequency converter. This amplifies the tuned RF signal before it is fed to the converter and so provides better performance on weak signals.

Cathode construction

The cathodes for all the above valve types can take two different forms. For battery operation, strands of wire are used and valves with directly heated cathodes suitable for operation from both 1.5V and 2V were produced.

By contrast, most of the valves encountered by restorers in mains-operated sets use indirectly-heated cathodes. This type of cathode consists of a fine metal tube with the heater wire inside and insulated from it. A big advantage of indirectly-heated valve cathodes is that the heater can be operated from low-voltage AC without introducing hum.

An exception in mains-operated sets may be the main (double diode) rectifier. This rectifies the high-voltage AC secondary of the transformer to provide the HT (high-tension) line and this valve is often directly heated.

Both directly and indirectly-heated cathodes employ special coating materials to ensure a good supply of electrons. In use, these materials gradually deteriorate, resulting in low emission and eventually making the valve unserviceable.

Other parts

Now for a brief look at other components. First, the electrolytic capacitors on the HT line in the power supply don't last for 50 years and if the originals are still there, they will need replacing. You can often tell from their appearance that they have failed, especially if they are leaking.

If there is any doubt, replace them with modern capacitors with a voltage rating of, say, more than 400V. The replacement values should be equal to or only slightly higher than the originals. In particular, note that substituting much larger value capacitors in the position immediately following the rectifier will invariably shorten the life of this valve, so don't do this.

Note also that the negative leads of these capacitors are sometimes connected to positions other than to the chassis. This means that you must check the lead connections carefully before removing the originals.

Low-value (non-electrolytic) capacitors and resistors are more reliable than electros. Most resistors can be checked in-circuit (with the power switched off) using a multimeter, while suspect capacitors can be removed and checked on a capacitance meter. One common problem in old sets is a noisy volume control. An aerosol contact cleaner may fix this problem but if the control is worn, replacement is the only answer.

Valve sockets and the pins of the valves themselves can also cause problems if the radio has been stored in damp conditions. Look carefully at the general condition of all metal parts – if they are corroded, this gives a good indication of valve socket problems

Power transformers are generally reliable, even after many years. The primary winding can be checked with a multimeter by measuring the resistance between the Active & Neutral pins on the power plug with the power off and the radio's on/off switch (if fitted) in the ON position. The primary winding will typically have a DC resistance of several hundred ohms.

If you have an insulation tester, check that the primary isn't breaking down to the transformer frame.

Valve testers

During the heyday of valve radios, valve testers were readily available. You simply removed the valve from its socket, set the controls of the tester according to a chart, plugged the valve into the tester and checked the reading on a meter. Although not totally foolproof, the results given by a valve tester were good enough for most purposes.

In fact, technicians who didn't know much about radio could often fix sets just by testing the valves.

Alternatively, they just replaced the valves in turn to determine which one (if any) was faulty. Such technicians were often derisively referred to as "valve jockeys".

Because they had to accommodate a wide variety of valves with different connection and power requirements, most valve testers were generally quite complicated. The most basic units tested the ability of the cathode element to emit electrons and checked for shorts between the elements. By contrast, the more sophisticated units also tested the valve's ability to amplify at varying power levels and usually required an experienced operator.

Making an instrument to test valves is impractical as a hobby project unless it is confined to simple tests on a particular series of valves. Instead, it is far easier to check valves in-situ by checking voltages (and sometimes current) while the radio in operation. In addition, an emission test on a valve tester can reject valves which may work perfectly well in low-power circuits.

The valves and other parts should also be checked visually (eg, are the valve heaters glowing?) but for other checks on the circuit, a multimeter is essential. Many basic digital multimeters (or DMMs) are available for $30 or less and these have a number of ranges to read current, AC and DC voltages and resistance. Nearly all DMMs have a high input resistance on the voltage ranges (typically 10MΩ) so that they don't disturb the circuit being measured.

If you don't have a DMM, buy one. You will probably pay less for it than you did for the radio!

The older-style moving-coil multimeters can be used for some measurements. However, their input impedance is much lower than for DMMs and this can lead to misleading results when making voltage measurements, particularly in high-impedance circuit. Even modern moving-coil multimeters have this problem.

Typical valve problems

OK, so what goes wrong with valves. Here are the most common problems and how to diagnose them:

(1) They lose emission – after a long period of use, the cathode (or filament) can no longer supply enough electrons to allow the valve to operate properly.

In practice, a valve's emission can be checked in circuit by measuring the current at the cathode. A valve data book can be helpful here, to give an indication as to what to expect. If the valve has a resistor from cathode to earth, simply measure the voltage across it and then calculate the current through it using Ohm's Law.

Power valves in mains-operated sets typically have cathode currents of 50mA, while other valves typically have values from 2-10mA. However, the cathode current will be lower for battery-operated sets.

(2) Vacuum is lost – when this happens, the cathode no longer emits electrons and so there will be no cathode current.

(3) Short-circuits between elements – this can be detected by checking the voltages around the valve. If elements are shorted, the voltages on them will be the same and will be incorrect.

(4) Open circuits – this particularly occurs with valves which have Bakelite bases, where wires from the elements are extended to the base pins. They can sometimes be repaired by re-soldering the base pins.

(5) Loose Bakelite bases and/or top caps – can be repaired by re-gluing.

This photo illustrates the size difference between an octal (8-pin) valve and a later 9-pin "miniature" valve. The 9-pin (and 7-pin) types dispensed with the Bakelite base, the valve pins emerging directly through the glass envelope.

8-pin octal valves

Untold millions of broadcast-band radios were manufactured in Australia between 1930 and 1960. AWA, Philips, Mullard, Astor and Kriesler are just a few of the brand names that come to mind. The early sets used valves with an 8-pin (octal) base and a glass envelope. Some valves also had the grid connection via a cap at the top.

The valve type was usually screen-printed on the glass. Basically, a valve with a particular type number complied with the standards set by agreement with a number of manufacturers. There were several sets of type-numbering standards, two of which were widely used in Australia – the American system and the European system.

For the American system, the starting number usually denotes the voltage for the heater or filament. Thus, a valve with a type number starting with "6" was designed for 6.3V while a type number starting with a 12 was designed 12.6V (this odd voltage comes from the fact that many radios were made for cars).

The last two letters denoted the type of envelope. "G" indicated a normal glass envelope, while "GT" denoted a smaller glass envelope. There were also valves produced with metal envelopes and for these the "G" or "GT" designation was simply left out. Metal

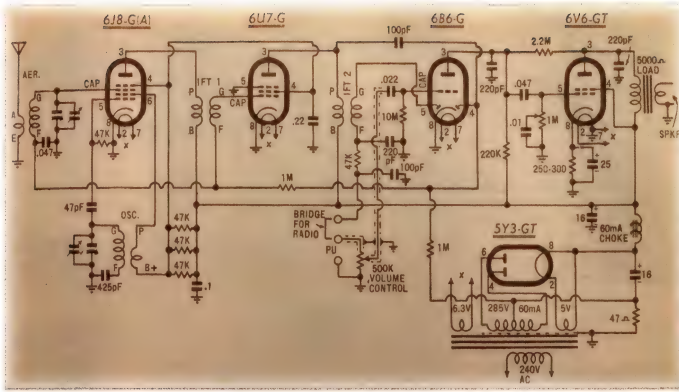


Fig.2: this was virtually the standard configuration for a mains-operated 5-valve superhet radio during the late 1940s and 1950s, although this particular circuit was actually published as the "ABC Five" in the August 1966 issue of "Electronics Australia". The "ABC" stood for "all bits collected".

valves were produced in relatively small quantities.

By contrast, European type numbers often started with letters to indicate the elements within the valve. An "A" usually indicated a diode, a "B" a triode and so on.

If your object is simply to restore historical radios, it isn't really necessary to become an expert on the thousands of valve type numbers. However, you should try to get a circuit diagram of the radio with the voltages marked and the base pin numbers indicated. A valve data book could also be useful or you could check the data on the internet.

Directly-heated valves

Inexpensive battery-operated radios from the 1950s typically used the following valve types: 1R5 (frequency changer); 1T4 (pentode IF amplifier); 1S5 (diode and pentode detector plus audio amplifier); and 3V4 (audio power amplifier – used to drive a small loudspeaker). These valves are of all-glass construction, have 7-pin miniature bases and had directly-heated cathodes.

A 1.5V battery is used to power the filaments, while a 90V battery (2 x 45V) is used for the high tension (HT) supply. By modern standards, the performance is not outstanding and a common problem with these valves is that the filaments tended to be unreliable.

A more rugged series of valves designed for battery-operated receivers was produced by AWV in Australia. These came in larger glass envelopes, with octal plastic bases and 2V filaments. Their power consumption was higher than the 1T4 series but they were more reliable and gave better performance. A number of military sets used the 2V series.

Indirectly-heated valves

Indirectly-heated valves were manufactured with a number of heater voltages: 2.5V, 4.0V, 6.3V and 12.6V, plus some with even higher voltages. However, the majority required 6.3V.

A simple mains-operated radio of the 1950s typically used the following valves: 6J8-G (triode heptode – frequency changer); 6U7-G (pentode – IF amplifier); 6B6-G (double-diode & triode – detector, AGC & audio amplifier); 6V6-G, (beam tetrode – audio amplifier); 5Y3-G (double diode – power rectifier). These are all 6.3V indirectly heated types except for the 5Y3-G which has a 5V heater/cathode and is operated from a separate 5V winding on the power transformer.

Combined with well-designed tuning coils and IF transformers, the performance of a radio with this valve line-up on local stations is more than adequate. In fact, the audio gain of the standard 5-valve mains-operated set has some reserve and the audio amplifier following the detector can be left out if very high volume is not required. This was the basis of the 4-valve "Little General" radio made popular in the 1940s by John Moyle who was the Editor of "Radio & Hobbies" (later to become "Electronics Australia").

It now more than 60 years since the original "Little General" was described in "Radio & Hobbies". Since then, transistors, ICs and large capacity memory chips have made mobile phones and digital radios both reliable and inexpensive. None of these consumer items are now manufactured in Australia.

Modern day marvels

John Moyle died in 1960. What would he have made of a little radio on sale in popular stores in the year 2010 for about $40 – an hour's working time for a skilled tradesman?

The type of set I'm thinking of typi-

Maurie Findlay – An Interesting Career

Maurie Findlay began his electronics career by making valve radios while still at school in the 1940s. He subsequently did a course to become a marine operator in his late teens and qualified for an amateur radio license at about the same time.

Being an avid reader of "Radio & Hobbies", he jumped at the chance when offered a job with the magazine in 1947. He subsequently left in 1953 to spend a year with Mullard-Australia as a sales engineer, just three years before the introduction of TV into Australia. His responsibilities included advising manufacturers on the best valve types to use in early TV receivers. During this time, he made a number of trips to Mullard's plant at Hendon in South Australia to study the manufacture and testing of valves.

Maurie then rejoined "Radio & Hobbies" for another five years. During his 10 years total with the magazine, he completed a cadetship as a journalist and studied part-time to become a professional engineer.

As well as being involved in the production of the magazine, Maurie also designed and described valve and later solid-state radio receivers, as well as amateur transmitters and test equipment. He hand-made the mobile radio equipment used by "The Sun" newspaper in the early 1950s and was generally involved in designing and testing the system. A major accomplishment at the time was his ability to eliminate receiver hash, due to the crude "vibrator" power supplies that were used!

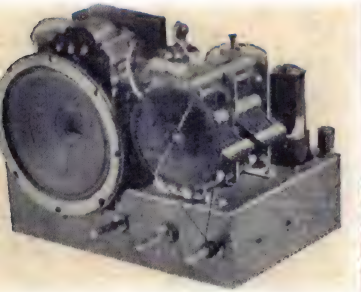
Maurie left "Radio & Hobbies" at the end of 1959 and joined the de Havilland Company as a trials engineer working on the "Black Knight" research rocket. This British-designed rocket was used to study the physics of re-entry into the Earth's atmosphere at very high speed. The aim, almost reached at that time, was 20,000 miles/hour (32,000km/h).

Maurie's responsibility on the Black Knight project involved the special tape recorder used in the re-entry head. He then returned to the company's plant at Stevenage in the UK to study the larger "Blue Streak" rocket.

Family responsibilities had priority over career and he subsequently returned to Australia to take up a position as Chief Engineer with Weston Electronics. Among other things, this company was involved in the manufacture of VHF transceivers and outback radio systems.

In 1962, Maurie formed Findlay Communications Pty Ltd which was to produce SSB marine equipment and mobile sets for use in the Royal Flying Doctor Service over a period of nearly 25 years. During this time, Findlay Communications also designed and supplied receivers and solid-state 1kW transmitters for the Australian Civil Aviation Authority.

Now retired, Maurie is a Member of the Institution of Engineers Australia and is still an active radio amateur with the call-sign VK2PW.



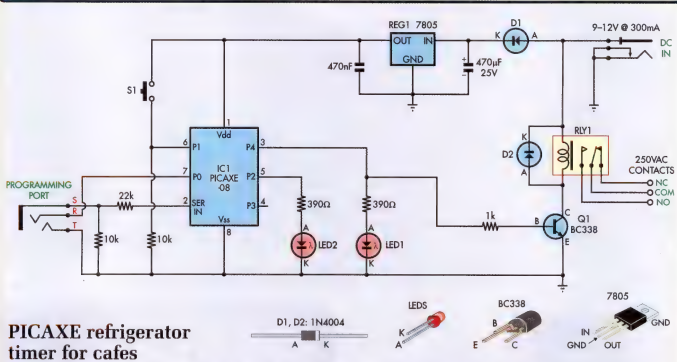
There were lots of "Little General" 4-valve sets described in "Radio & Hobbies" over the years. This one was described in January 1946 by Neville Williams and is closely based on the design originally published in the April 1940 issue by John Moyle. The valve line-up was as follows: 6J8-G, EBF2-G, 6V6-G and 5Y5-G.

cally measures no more than about 100 x 60 x 30mm and is powered by two AA cells which last for about a month with typical usage. It features not only an AM broadcast band but shortwave, stereo FM and an inbuilt digital clock with alarm features as well. And of course, digital tuning and a preset station memory are all part of the deal.

John Moyle was an imaginative and resourceful man. He would almost certainly have come up with some new angle. I knew him well. SC

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



PICAXE refrigerator timer for cafes

This timer was designed to temporarily switch a cafe refrigerator off, to reduce background noise when a meeting was being convened in the cafe area. It provides automatic switch-on after an adjustable period of at least two hours. This avoids the refrigerator being inadvertently left off.

With the current software, the timer has a settable range of 10-180 minutes in 10-minute increments but with some appropriate software tweaks, it has a capability of milliseconds to about 49 days.

With change-over contacts on the relay, the timer could switch the load on or off for the timing period, for other applications.

The timer is based on a PICAXE-08M microcontroller. It is toggled on or off whenever pushbutton S1 is pressed. LED1 and the relay are on when the pin 3 output is high during timing mode. LED2 flashes when the pin 5 output is high during timing and gives an indication of the time delay remaining by varying the mark-to-space ratio of the flash.

If the LED flash is long, the time delay has only just started; if the flash is short, the time is almost up.

Q1 is an NPN transistor that switches the load via relay RLY1. Diode D2 protects against relay coil back-EMF and diode D1 provides power supply reverse polarity protection.

The relay should have contacts rated for 250VAC and 30A, to cope with the surge current of the induction motor in the refrigerator. Suitable units would be a Jaycar SY-4040 chassis-mount type with SPST contacts or Altronics S-4211 chassis-mount with SPDT contacts.

Pins 2 & 7 provide the standard serial programming interface. The time delay can be preset within specific parameters via a special set-up mode when the circuit is powered up or to a wide range of delay times by software changes. LED2 flashes once for every 10 minutes of time delay set, whenever the unit is powered up. For example, six flashes indicates 60 minutes.

Set-up mode is obtained by holding down pushbutton switch S1 until a series of rapid flashes from LED2 is observed. The time delay setting is then incremented by 10 minutes for each subsequent press of S1. As during start up, indication of the time selected is provided by LED2 flashing once for every 10 minutes of time delay.

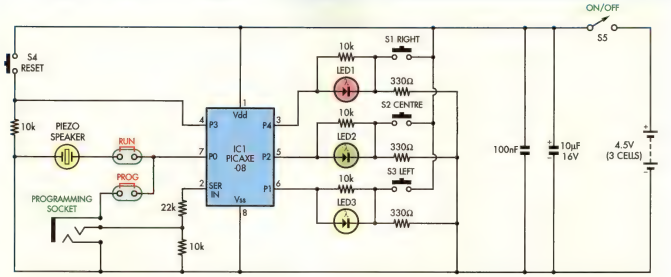
When the setting of 180 minutes (18 flashes) is exceeded, the delay rolls over to 10 minutes (one flash). The delay is written to EEPROM so that the setting is retained even with power disconnected. The set-up mode is completed by powering off, waiting a few seconds (for the power supply capacitors to discharge) and then powering on again.

The delay selected (in 10 minute-increments) is again indicated by the number of flashes of LED2.

The PICAXE program can be adjusted to suit the timing application required. Accuracy of the timer depends on the internal PICAXE08M clock and was found to be about 40 seconds slow per hour. This can be adjusted in the software if more accuracy is required.

The software, CafeTimerV4.bas, can be downloaded from the SILICON CHIP website.

Philip Webb,
Hope Valley, SA. ($40)



PICAXE I/O demonstrator circuit

SILICON CHIP has published many projects based on the PICAXE-08M microcontroller and they have all had one thing in common: the inputs are inputs and the outputs are outputs. The bi-directional input/output (I/O) pins are not used as both inputs and outputs in the same program.

This circuit has been devised to demonstrate how this may be done. Three of the PICAXE pins are fitted with pushbuttons as input devices and LEDs as output devices.

In each case, input current flows through the pushbutton and a 10kΩ resistor while the output current passes through the LED and a 330Ω resistor. When operating as an input, the LED is reverse-biased by having its cathode connected to the positive rail each time the pushbutton is pressed and the input is pulled high via the 10kΩ resistor.

Current also flows through the 330Ω resistor to the 0V rail and while this resistor places extra load on the battery supply, it has no effect on the way the input operates.

When operating as an output, the 10kΩ resistor can be ignored, with the current passing through the forward-biased LED and the 330Ω resistor to the 0V rail. One other possibility is for someone to operate the pushbutton while the output is being driven. Once again the LED will be reverse-biased and any current will be limited by the 10kΩ resistor to prevent damage to the PICAXE output. While the button remains pressed, the LED will also turn off. This should not cause a problem in most programs.

These concepts could be extended, with the output LEDs being part of an optocoupler and by adding driver components there is the possibility of controlling relays, horns and various other devices while still retaining the combined I/O circuit concept.

As far as programming is concerned, note that when a PICAXE-08M powers up, the bi-directional pins are set as inputs. If outputs are needed, these must be set up by the program.

The program can also restore the pin to an input if needed.

When setting up an output, you have a choice of setting it high (on) or low (off). This is not necessary with inputs where the logic state is determined by the voltage on the pin.

Three demo programs have been written to give examples. The listing is **3demogames_pgm.bas** and will be available for download from the SILICON CHIP website.

Ian Robertson,
Engadine, NSW. ($40)

Contribute And Choose Your Prize

As you can see, we pay good money for each of the "Circuit Notebook" items published in SILICON CHIP. But there are four more reasons to send in your circuit idea. Each month, at the discretion of the editor, the best contribution published will entitle the author to choose the prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser, an ESR60 Equivalent Series Resistance Analyser or an SCR100 Thyristor & Triac Analyser, with the compliments of Peak Electronic Design Ltd – see **www.peakelec.co.uk**

So now you have even more reasons to send that brilliant circuit in. Send it to SILICON CHIP and you could be a winner.

You can either email your idea to silchip@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.

Magnetic pole & flux strength indicator

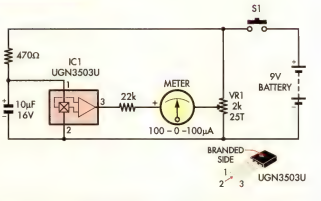
This circuit can identify whether a magnet's North or South pole is placed against it and gives a rough indication of the magnetic flux density and hence the strength of the magnet. It is based around a ratiometric linear Hall Effect sensor (IC1 – UGN3503U, Jaycar ZD-1902). This will run from 4.5-6V but for convenience the meter has been designed to run from a 9V battery.

IC1 draws 8-12mA depending on its supply voltage and manufacturing variations. The series 470Ω resistor ensures that even at the lowest current level, the voltage at pin 1 does not exceed 6V.

A 5V linear regulator (eg, 78L05) could be included for extended battery life. This should be used to power the whole circuit (including VR1), in which case the 470Ω resistor is replaced with a link. A low dropout, low quiescent current regulator (eg, LP2981) would be even better.

Power is applied via pushbutton switch S1. Since it is not a latching switch, the meter cannot be accidentally left on. The 10μF capacitor bypasses the supply and smooths out any voltage spikes which might occur initially when the meter is switched on.

IC1's output is around half-supply (typically 2.5V) in the absence of a magnetic field and the output voltage increases or decreases with the detected field, depending on its polarity. Potentiometer VR1 is adjusted so



that no current flows through the moving-coil meter in the quiescent state. The 22kΩ resistor, in combination with VR1, converts IC1's output from a voltage to a current that so it can drive the meter.

If a south magnetic pole is placed near the branded face of the sensor, its output will go positive and the meter will deflect to the right. A north magnetic pole will cause it to deflect to the left. The meter is not calibrated so it can only give an indication of relative field strength. For use with very strong magnets, the 22kΩ resistor may need to be increased in value (eg, to 33kΩ) if the meter range is insufficient. Alternatively, better resolution can be achieved for weak magnets with a lower-value series resistor.

Brett Cupitt,
Ashfield, NSW. ($30)

Automatic exterior light

This circuit switches on an outdoor light for an adjustable time period when light from other sources, such as car headlights, is detected during the night.

There are three light sensors: LDRs1-3 (ORP12 or a similar type). They are mounted in weatherproof housings, each with a magnifier lens orientated in the appropriate direction. LDR1 and LDR2 are used to trigger the lamp in response to light while LDR3 monitors the ambient light level, to avoid turning on the light during the day.

Power is derived from a 9V mains transformer. Its output is rectified with a full-wave voltage doubler, providing roughly 24V which is then regulated to around 12V by a discrete regulator comprising NPN transistor Q1 and 13V zener diode ZD1.

Each LDR is used as half of a voltage divider with the other half consisting of a fixed and a variable resistor. The resulting voltage is compared to a half-supply level (about 6.2V) formed by fixed voltage dividers made up of 47kΩ resistors.

Op amps IC1-IC3 are used as comparators. By adjusting trimpot VR1, LDR1's sensitivity to light can be varied and similarly with VR2 and VR3 for the other two LDRs.

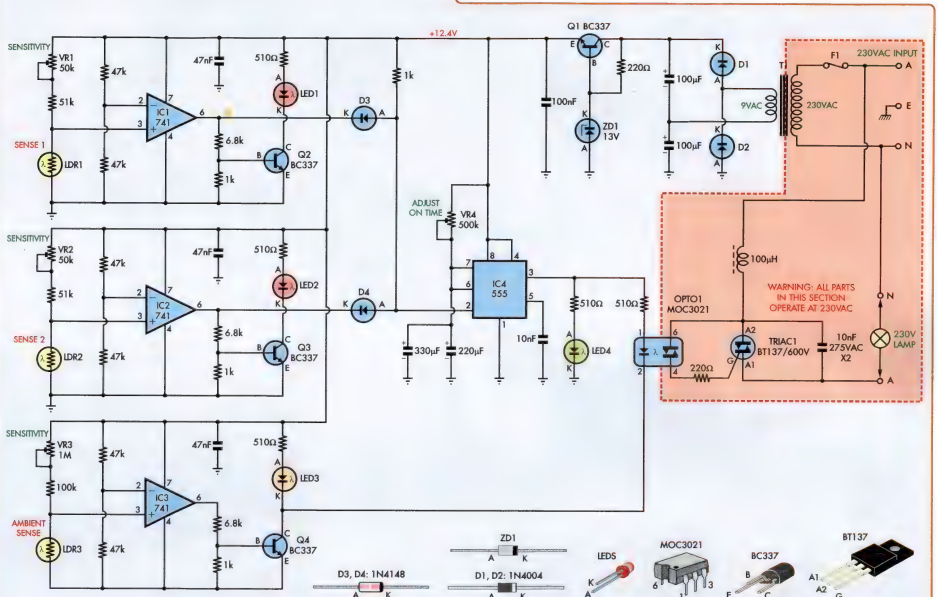
When light falls on an LDR its resistance drops. When the light is bright enough (as determined by its associated potentiometer), the voltage at the associated op amp's non-inverting input voltage becomes lower than that of its inverting input. As a result, the op amp's output swings low, switching off the driven NPN transistor (Q2, Q3 or Q4). This turns off the indicator LED (LED1, LED2 or LED3).

Op amps IC1 & IC2 control 555 timer IC4. It is configured as a monostable oscillator with its time-constant set by trimpot VR4. Its trigger input is normally held high by a 1kΩ pull-up resistor but when light falls on either LDR1 or LDR2 and the associated op amp output goes low, the trigger pin is pulled low via either diodes D3 or D4, triggering the timer.

When triggered, pin 3 of IC4 goes high, lighting LED4. If it is night time, current will also flow from this output through the internal LED of optocoupler OPTO1, then through Q4 to ground. During the day, Q4 is switched off so OPTO1 will not be activated.

When OPTO1's LED is powered, the gate of TRIAC1 is connected to the mains Active line via a 220Ω resistor, triggering the TRIAC and turning on the external 230V AC lamp. When IC4 is triggered, the paralleled 220μF and 330μF capacitors are discharged but they then slowly charge via VR4 and after the chosen time period the timer switches off the lamp, ready to be triggered again.

Rob Leplaw,
Oatley, NSW. ($45)



This automatic exterior light circuit uses three LDRs to sense the light conditions and control comparators IC1-IC3. IC1 & IC2 control 555 timer IC4 which in turn drives optocoupler OPTO1 and TRIAC1 to switch the lamp. LDR3 & IC3 turn Q4 off during the day, so OPTO 1 will not be activated.

6-stage cascaded timer uses SCRs

This circuit turns on six LEDs in turn with each one lighting for a preset time. With relays in place of the LEDs, it could be used to control six separate functions such as lights on a model railway layout.

Each LED or relay is switched via a 2N5060 SCR and there are essentially six identical SCR sections which are cascaded. The first SCR is triggered on by pressing start switch S1 which applies voltage to the gate.

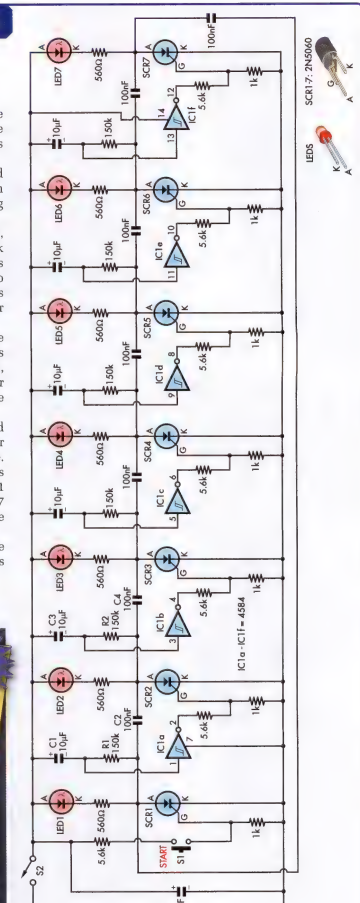
When each SCR switches on its LED or relay load, it also applies the supply voltage to an RC network consisting of a 10µF capacitor and 150kΩ resistor. This causes the voltage at the junction of the RC network to drop slowly as the capacitor is charged. This voltage is fed to one input of a 4584 CMOS hex Schmitt trigger inverter, IC1.

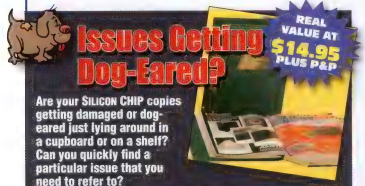
So after SCR1 has been triggered on, the voltage at the pin 1 input of 1C1a will eventually drop to its threshold voltage and the pin 2 output will go high, triggering SCR2 and thereby turning on its LED (or relay). SCR2 also turns off SCR1 by pulling its anode low via 100nF capacitor C2.

SCR2's RC network is then brought into play and it turns on SCR3 after the associated 10µF capacitor C2 has charged sufficiently for IC2a to change state. SCR3 turns off SCR2 via C4 and so the process goes on until SCR7 is turned on. It stays on until switch S1 is pressed to trigger SCR1. SCR1 then turns off SCR7 via the associated 100nF capacitor and then the whole timing process is repeated.

The time delay for each LED, except LED7, can be varied by changing value of the resistors or capacitors in the RC networks.

A. J. Lowe,
Bardon. Qld. ($40)





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GPS Car Computer enhancements

I am writing in relation to the GPS Car Computer featured in the January 2010 issue. Unless I have missed something in the article, it appears that the basic "GPS Car Computer" has no on-board memory in which to store collected data for later analysis on a desktop PC via the USB port. The article seems to suggest that a laptop computer has to be connected to the GPS-CC when the vehicle is being driven in order to be of any value.

So my question is could a future project be designed that adds a non-volatile memory component to this very useful device and software provided for installing on any PC, so that a full trip profile can be obtained at the conclusion of the trip? In the interest of road safety it would obviously be impractical to use the device connected to a laptop if the driver were to be the sole occupant of the vehicle. It could only be used in this configuration when there is a passenger and as such, couldn't be used as a satnav replacement at all times.

Although the GPS-CC device is obviously not a replacement for the "Davis Instruments CarChip", a version of which was reviewed in SILICON CHIP sometime ago, the DICC does allow for data to be downloaded at the completion of a journey for later analysis. (P. M., Karabar, NSW).

● We put your questions to the designer, Geoffrey Graham and this is his reply:

You certainly have a high level of requirements! Regarding tracking a journey: it could be done but it would take a redesign, the main difference being that a microcontroller with much more flash memory would be required.

This type of chip is cheap enough but they are mostly only available in surface-mount TQFP packages with 0.2mm between the pins (three times the width of a human hair!). They can be soldered (I have done it) but you do need to be adventurous and prepared to ruin a chip or board or two.

Also, you are right. It is not a replacement for the "Davis Instruments CarChip". That was a completely different beast and much, much more complex.

Fuel mixture display needs air-flow input

I purchased a Smart Fuel Mixture Display kit (SILICON CHIP, April 2004). On installing it into the original set-up in car with an oxygen sensor and air-flow meter all works fine. My problem arose when I removed the air-flow meter, due to fitting a set of throttle bodies which have no air-flow meter. Is it possible to use the throttle position sensor instead of the air-flow meter? (J. W., via email).

● As the name suggests, "throttle position sensor" indicates throttle position rather than engine load. However, it could be used instead of the air-flow meter with the understanding that the throttle position does not always match the engine load, especially in low gear.

Comparing electricity and gas for heating

Over recent months, you have been discussing various forms of energy and their relative properties, advantages and disadvantages. This question may not be within the parameters you generally answer but I thought that SILICON CHIP was a good place to start.

I have heard in the past that reverse cycle air-conditioning is the cheapest form of heating. In our lounge room we have a gas room heater (fan assisted) as well as reverse cycle A/C. Is it better

Upgrading The 12V Battery Charge Controller

I have just read a reply in "Ask SILICON CHIP" for May 2010 about a 24V modification for the 12V Battery Charge Controller published in the April 2008 issue. It occurred to me that this could possibly solve my problem with a 48V golf-cart charging system.

The bank has six 8V Trojan T-875 wet cell, deep-cycle batteries which I am charging with a standard 48V centre-tap transformer/twin-diode type charger. However, I would like to upgrade it to the battery charge controller system.

Would this be possible? As far as I can determine the RC for these batteries is 295 (295 minutes @ 25A), or a 125Ah rating. My charger supplies up to 20A on start up.

If what I ask is not viable can you suggest an alternative or, better still, can you describe a golf cart charger with dual voltage 36V and 48V outputs? (J. N., Mt. Maunganui, NZ).

● The 24V modification for the float charger as described in the May 2010 issue was for the March 2003 charger. However, the April 2008 charger design could be modified for 36V and 48V.

For 36V, use a 330Ω 0.5W resistor for the feed resistor from diode D1 to 24V zener diode ZD1. Also for 36V, the divider at pin 2 needs changing – use an 82kΩ resistor instead of 22kΩ for R1.

For 48V, use a 2.2kΩ 5W resistor for the feed resistor from diode D1 to the 24V zener diode ZD1. Also for 48V, use 120kΩ for R1. Mosfet Q1 will require changing to a 100V type such as the IRFB59N10DPBF (100V 60A). This is available from Farnell, Cat. 864-8786.

Use 20A wire and a 25A fuse. You may also wish to thicken the current carrying tracks with solder.

Dual-Purpose Battery May Not Be The Best

The battery in my vehicle is possibly approaching the end of its life as its open-cell voltage is around 12.3V, although it still starts the vehicle reliably. I was considering purchasing an all-rounder type which claims to be both a deep-cycle type and to have a good cold-cranking characteristic. This would suit me on camping trips for the occasional use of my Waeco compressor fridge overnight.

My Subaru Forester does not have space for an extra battery under the bonnet so I thought this idea has some merit. The fridge has a low voltage cut-out feature so over-discharging the battery is unlikely. I vaguely remember some articles some years ago in SILICON CHIP indicating that car charging systems never charged the vehicle battery beyond 70% of its capacity.

Is this correct and would I be deluding myself buying this type of battery for a dual-purpose use? (M. T., Donvale, Vic).

● The open-circuit voltage does not indicate whether a battery is nearing the end of its life. A battery's voltage is dependent on its charge state, temperature and the time since it was last charged or used. Its voltage will drop with load and the fact that the car starts reliably suggests the battery is still OK.

Conditions for a battery in a vehicle are not ideal because it operates at high temperatures and the battery is charged to its end-point voltage (that does not appear to have temperature compensation in most cars) and it is not brought back to float charge voltage (lower than the end-point voltage) after full charge.

In addition, a car battery needs to be designed for the heavy cranking current required by the starter motor and this means that it has thin plates that allow rapid current delivery. A deep-cycle battery on the other hand may not have sufficient cold cranking capability since the plates in these batteries are heavier. It's unlikely that a battery that's claimed to have a high cold-cranking current would also be a deep-cycle type. Instead, it's likely to be a compromise construction for both applications.

The state of charge for a car battery really depends on the alternator current that can charge the battery and drive the battery load. Battery load can be higher than the alternator current if the lights and accessories like the sound system are all on and the engine is idling.

It may be more advantageous to use a larger battery designed for cars (with the cold-cranking capability) rather than opt for a compromise design battery that may be better for deep-cycle applications.

(read cheaper) for us to use electricity (A/C) or gas to obtain winter warmth? (K. J., via email).

● That's a very interesting question. There are a number of factors to be considered. The first of these is the energy tariffs for gas and electricity. Depending on where you live in Australia and how much you consume each quarter (three months), the domestic electricity tariff can be anywhere between 16 and 20 cents per kilowatt-hour + GST.

If you are unfortunate enough to have opted for a Smart Energy Meter (Smart for the Electricity Retailers; really dumb for the consumer!), your tariff in peak periods could be up to 40 cents/kilowatt-hour or in some special cases, up to $2/kilowatt-hour. But for most people, the rate is around 20 cents/kilowatt-hour.

By comparison, after do you the conversion from gas units to megajoules, to kilowatt-hours, the typical rate for gas is 7 cents/kilowatt-hour (including GST). In Sydney, this is comparable to the rate for off-peak electricity (for hot water systems). All of the above information can be gleaned from your quarterly bills for gas and electricity (3.6kWh = 1 megajoule and the gas rate is 1.95 cents/megajoule).

The second factor to be considered is the efficiency of reverse-cycle air-conditioning. Typical domestic air-conditioners have a coefficient of performance (COP) of around three which means that they will pump 3kW of heat while consuming 1kW of electricity. However, they are not so efficient when they are used for heating and the outside air must be reasonably warm. By the time the outside air drops to 4°C or below, air-conditioners no longer work. Commercial units have electrical booster elements so they can still maintain comfortable conditions but that means their efficiency is the same as for electrical heating.

By the way, the Star rating used for air-conditioners in Australia is effectively useless in trying to make these comparisons.

Gas heating is typically more than 90% efficient and can be higher in the case of some flued gas heaters (see the Publisher's Letter, June 2010).

So what is the answer? If you live in an area where you have lots of

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FM Transmitter For Christmas Lights Display

I am hoping you may be able to assist me. I am after a small FM transmitter that could transmit Christmas Carols to cars driving past our light display. The plan is to have a sign with the frequency on the fence, then if people choose they can listen to our carols. This will mean we don't need to have the speaker volume as loud.

I am wondering if there are any stores in Victoria that sell something like this? (C. H., Chadstone, Vic).

● Great idea, Colin. We published FM stereo transmitter projects in April 2001 and December 2002 but they have now been discontinued. You could probably still build one of them provided you could still obtain the relevant transmitter IC. However, you can buy these units as audio accessories from places like JB Hifi or eBay.

Just coincidentally, we are working on a Christmas Lights Controller which will be able to provide programming of multiple light channels synchronised with music stored on an SD card. We hope to publish the first article next month.

frosts and the outside air temperature is often below 10°C, the chances are that your gas heater is more efficient and cheaper to run than reverse-cycle air-conditioning.

A practical way to test this would be to heat your room or house for several nights with gas and then do the same thing with the aircon. Compare the electric and gas consumption in both cases to get the answer.

One final aspect to consider is greenhouse gas emissions. In the case of the gas heater, all the chemical energy of the gas is consumed in the heater and it is a relatively efficient process. In the case of the air-conditioner, most of the electricity it uses comes from coal-fired power stations in Australia and so the thermodynamic efficiency of that process must be considered as well as the transmission losses from the power station to your home. We would estimate the overall conversion efficiency from coal to electricity in your home to be not much more than 30%. When all that is considered, gas is probably the best way.

Power window time delay wanted

I was wondering if you have ever designed a kit which allows the power windows to be operated without the ignition being on in cars with ECU's controlling the windows? It was easy in the good old days when all that was involved was a relay and the door switches. Even a method of extending the "power on" delay after turning off the ignition would be a big improvement. I would like to modify my Lexus RX330. (N. S., Hamilton, NZ).

● Unfortunately, with central locking and power windows being controlled via the car's ECU (or more correctly, the Body Computer), there is no easy way of extending the power window use when the ignition is off. Some cars allow the windows to be operated for a limited time after the ignition is turned off but before any doors are opened.

We have not developed a project that would do the modification you require. The Turbo Timer projects from August 2007 or November 1998 could perhaps be used to maintain power to the window motors after the ignition is switched off for a period of time. However, whether the window actuating switches would work depends on the car and how these are connected. They may be monitored via the Body Computer instead of just controlling the window mechanism itself.

Wrong readings from digital thermometer

I have finished building the High Temperature Digital Thermometer from "Performance Electronics for Cars". I believe I have done everything correctly but the issue I have with this unit is that the display reads in negative figures. The figures are still valid, ie, 30° is still 30° and 20° is 20° and so on, it's just that it reads negative when it should be positive.

I have tried reversing the thermocouple connections but as described in the construction notes, temperature readings go down when they should

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Monster Class-A Amplifier Is Not Practical

I recently purchased two Studio 350 Amplifier modules (SILICON CHIP, January & February 2004) and have been looking at the circuit. I was wondering whether it was possible to lower the supply rails to ±55V and to increase the quiescent current to 1.8A. This would run the amplifier in Class-A up to 50W before running in Class-B.

The amplifier would need to dissipate about 200W of heat so I would need a large heatsink, possibly forced air-cooling. I would obviously need to increase the value of VR2 in the V_{be} multiplier.

Would there need to be any other component value changes made to the circuit? Any suggestions would be greatly appreciated. (S. H., via email).

● What you propose is certainly feasible and no circuit changes should be necessary. Just reduce the supply rails to ±55V and adjust trimpot VR2 to give a quiescent current of 1.8A.

However, we would not do it. For a start, your modifications will mean that you only get class-A operation up to about 25W, not 50W into an 8-ohm load. Into a 4-ohm load you would only get about 12.5W.

Second, you will need more filter capacitors to get the hum on the supply rails down to reasonable levels. You might need 40,000μF or more on each supply rail and you would need to incorporate the supply rail modifications featured in our 20W Class-A design described in May 2007.

Even if that is satisfactory, the transformer will radiate a much bigger hum field and will probably buzz quite audibly. In fact, you might need to put the power supply in its own enclosure.

You will also need a fan-cooled tunnel heatsink and the fan will need to run continuously; another source of noise. You will also substantially reduce the maximum power output by dint of reducing the supply rails – from 200W down to about 125W into 8-ohm loads and from 350W down to about 215W into 4-ohm loads, although that will not make a big audible difference.

Frankly, the more we think about it, the less we like the idea. You will be significantly compromising the performance just to get the supposed "ideal" of Class-A operation. Just because an amplifier is running in Class-A does not make its performance above reproach.

If we wanted to improve on the Studio 350 design, we would simply try upgrading the output transistors from MJL21193/4 to MJL1302A and MJL3281A types, respectively. These latter output transistors are significantly more linear and should give lower distortion at the higher frequencies.

go up etc. As it is the CX101b model, the digital readout is wired as per Fig.4 on page 63.

It calibrates correctly and setting the trip point works if I set it to a negative temperature but then remains tripped if I set to a positive number (as it would because if it is reading backwards, then ambient temperature would be far above the trip point and so would not become "untripped" until the ambient temperature reaches minus whatever you set it to).

After reversing the thermocouple connections I set VR3 so that the reading was the same as ambient. However, on checking calibration with the probe removed and the wire from the positive thermocouple terminal to TP2 (as per the calibration instructions), it is some 50°C out. Have you any ideas? (R. S., Lake Grace, WA).

● Try swapping the connections to INHI and INLO on the LCD module so that the negative readings are correctly showing a positive value. The thermocouple probes need to be correct, with the positive and negative leads oriented correctly, otherwise the compensation circuit will be incorrect and this would probably account for the 50°C error.

Notes & Errata

Dual Tracking ±0-19V Power Supply (June-July 2010): there are two errors in the circuit diagram of Fig.2 in the June issue. The 820Ω resistor connected to pin 1 of IC4a should be 68Ω while the 100kΩ resistor from Vout- to the top of VR7 should be 10kΩ.

The layout diagram (Fig.8) in the July 2010 issue is correct.

In addition, the wiring diagram (Fig.11) shows the top and bottom connections to the VOLT ADJ header (CON6) transposed. Also, the leads to pins 5 & 6 on the panel meter must be transposed for the Altronics display.

Remote Controlled Digital Up/Down Timer (August 2010): the relay contacts are incorrectly shown by the screened overlay on the PC board. The parts layout diagram of Fig.2 is correct. In addition, the LED display part numbers are incorrect. These should be 7DR8021BS and 7DR5621BS.

A couple of minor issues have also surfaced in the software. First, the alarm period is skipped if the external trigger is active when the countdown ends. Second, the device ignores infrared signals if the reset and trigger inputs are on simultaneously. The updated firmware (1910810B.hex) fixes both issues and has been forwarded to the kit retailers.

Single-phase to 3-phase converter wanted

I have a suggestion for a possible SILICON CHIP project. I bought some secondhand machines that have 3-phase 415V motors but I only have a single-phase 230VAC supply to my house and workshop. Variable frequency drives (VFDs) are available to allow 3-phase motors to run from single-phase power but these seem more elaborate than they need to be.

I can't find anything that will keep

... continued on page 103

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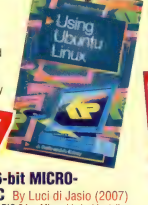

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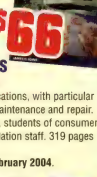

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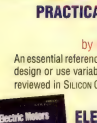

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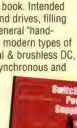

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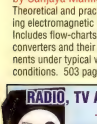

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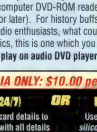

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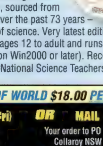

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Ask Silicon Chip – continued from page 98

the frequency as is and just provide three phases so that the motors will operate at only one speed.

The machines have their own arrangements for varying speed mechanically; all that I really need. I don't even need reversing capability. Also, commercial VFDs all seem to have displays and multiple switches for speed variation and these add to the complexity and cost which is not insubstantial.

I am wondering if there is scope for a DIY project that can provide for a simpler solution to the need for operating 3-phase motors from a single phase supply? I understand that there is a variable – delta or star wiring – that needs addressing. But assuming a motor is configurable either way, a 230V 3-phase output should be all that's needed. (J. P., via email).

● Back in April 2000 we featured an article on how to run 3-phase motors from a single-phase 230VAC supply. It involves using some 440VAC capacitors but no electronics.

3-speed fan controller capacitors

I wish to know if it is possible to purchase the capacitor module that controls the speed of ceiling fans. I have six fans that need attention, mainly with the second speed setting.

I have checked the capacitance of some units and found that the value of the unit in some cases is half of what it should be, eg, 2.5µF reads 1.2µF. I have checked the fan motor capacitors and they are within 5% of their rated value.

I visited a couple of electrical stores here and they want to sell me a complete controller for nearly the price of a new fan. There is nothing wrong with the fans or control switch, only the capacitor block is faulty, so is it possible to just buy the capacitor module? The values required are 1.8µF and 2.5µF.

I know that there are other values of capacitance for other fans. The type of fan I have is a Wattmaster 3-speed ceiling fan. I have checked on the web at Wattmaster but can't seem to find any information regarding capacitors. (B. H., Mackay, Qld).

● Depending on the size of the fan, motor start capacitors could be used for large fans or mains-rated polypropylene X2 capacitors can be used for smaller fans. Ideally, use the same type of capacitor that is already in the fan speed controller.

Polypropylene X2 capacitors are available from Farnell (**www.farnell.com.au**) – Cat. 111-2847 for 1.5µF and 111-2849 for 2.2µF. You can add 330nF across each to make up the values to 1.8µF and 2.5µF. A 330nF X2 capacitor is Cat. 111-2844.

For motor start capacitors, see Cat. 119-0561 for 1.5µF, 119-0562 for 2µF and 119-0563 and 3µF. SC

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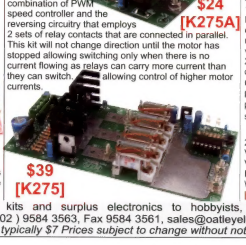

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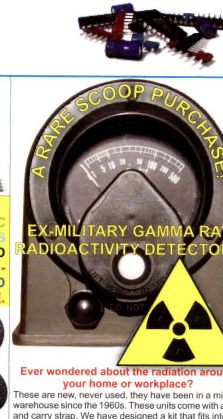

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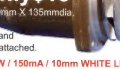

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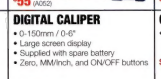

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COUNTERSINK SET

- Metric 6-20mm

$55 (D105)

HOLE ENLARGING DRILL SET

- 3 piece set

$65 (D107)

DRILLING MACHINE

- 1HP 240V
- 16-speed
- 16mm drill capacity
- 170mm throat depth
- Medium duty

$259 (D138)

+ FREE VICE (V125)

AL-280P LATHE MILL DRILL

- The drill head swings 90° in both directions and has 14 spindle speeds
- Fine micro down feed is incorporated for milling operations
- Quick action spindle engage system transferring drive from lathe to mill
- Milling vice incorporated within compound slide
- Metric and imperial screw cutting
- Chuck guards for lathe and drill chuck
- Sheet metal leadscrew cover
- Power long feed on saddle
- 400mm swing
- 3/4hp 240V motor
- 19mm spindle bore
- 3MT spindle and tailstock
- Includes: 3 & 4 jaw chuck, back plate, dead centre, keyed drill chuck & arbor, set of change gears & toolbox

+ FREE (L009) 6 PCE TOOL KIT

$1,295 (L159)

ENGINEERS FILE SET

- 5 piece, 200mm second cut
- Cushion grip handle
- Contains: flat, 1/2 round, round, square, triangular

$29 (F100)

FITTING & MACHINING BOOK

- 639 pages of technical information
- Hard cover

$69 (L341)

HM-10 MINI MILL DRILL

- 350W, 240V motor
- 385mm x 93mm table
- Electronic variable speed
- 2 speed gearbox
- Head tilts ±45° both directions
- Ground work table with T-slots
- Spring return assisting milling head
- Vertical micro feed dial .025mm
- Metric dial graduations 0.02mm
- 2-speed gearbox (high / low) drive system to maximise torque
- Travels: (X) 228mm (Y) 100mm (Z) 190mm

$825 (M150)

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Specifications & Prices are subject to change without notification. All prices include G.S.T. and valid until 26-10-10 (*WA prices may be higher due to freight costs)